adiCET

The 1st International Conference on Smart Community Development in the Asia Pacific (iSCAP2020)

February 21st, 2020

Asian Development College for Community Economy and Technology (adiCET)
Chiang Mai Rajabhat University, Chiang Mai, Thailand

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Dean's Message

Asian Development College for Community Economy and Technology (adiCET), Chiang Mai Rajabhat University was found in 2010 with the strong aims to integrate education, research and academic services for sustainability in community development, energy and environmental technology, renewable energy management, and green technology. On the occasion of adiCET 10th anniversary, "10th Anniversary: 10 years of Developing Community Power" and "The 1st International Conference on Sustainable Development Goals for Smart Community in the Asia Pacific Region (iSCAP2020)" are organized and held for the purpose of providing a platform to share knowledge and research experiences, and form a collaboration with networks for research development. Additionally, the platform provides guidelines for development of quality standards in research and graduate education in accordance with Graduate Program Criteria by Office of the Higher Education Commission (OHEC). The platform also gives an opportunity for graduate students to present their research findings and publish to the public.

Asian Development College for Community Economy and Technology, Chiang Mai Rajabhat University has cooperated fully with very experienced and knowledgeable experts and academicians in different fields to evaluate academic contributions for this conference. Therefore, research papers that are published in the conference proceedings are considered high-quality. Our college sincerely hopes that the conference is beneficial to both participants and those interested in making practical use of research contributions. I sincerely extend our thanks to all academicians, lecturers and personnel who have participated in this conference.

Dr. Worajit Setthapun
Dean of Asian Development College for
Community Economy and Technology
Chiang Mai Rajabhat University

Editor's Message

"The 1st International Conference on Sustainable Development Goals for Smart Community in the Asia Pacific Region (nSCAP2020)" is under the "10th Anniversary: 10 years of Developing Community Power" which is held on February 20th – 21st, 2020 at Asian Development College for Community Economy and Technology (adiCET), Chiang Mai Rajabhat University (Mae Rim Campus), Chiang Mai. The purpose of the celebration is 1) to promote academic collaborations, knowledge sharing, and research experiences between scholars, lecturers, Chiang Mai Rajabhat University students, and network institutions, 2) to promote and support lecturers, researchers, and students in presenting research in order to build its reputation for academic excellence both nationally and internationally, 3) to advance university's research collaboration networks and enhance reputation in academic circles.

Selected research papers published in the conference proceedings are evaluated and accepted, solely on the basis of quality and importance in accord with journal quality criteria, by experts and academicians from several institutes based on their expertise and prior work in the area. 30 selected research papers from a total of 12 different universities and 3 Countries were accepted, within the diverse fields of community energy, environment, community innovation and socially-engaged research in which the research contributions strengthen community development.

Conference committees would like to express our appreciation to all participants and presenters as well as distinguished guests who participate in, and contribute to the accomplishment of the conference.

Dr. Nuttiya Tantranont

Editor

Agenda The 1st International Conference on Smart Community Development in the Asia Pacific (iSCAP2020)

Asian Development College for Community Economy and Technology, Chiang Mai Rajabhat University

21st February 2020

Session 1: WEF Nexus; Renewable Energy & Environment
Session Chairs: Assistant Professor Dr. Saoharit Nitayavardhana
Assistant Professor Dr. Rotjapun Nirunsin

Room 1: AREC

Time	Topic
09:00-09:12	Experimental Study on Strength of Concrete with Partial Replacement of Fine Aggregate with Brick Waste by Pyae Su Htike
09:12-09:24	Estimation of Runoff Potential in Sittaung River Basin Using GIS Application by Thet Hnin Aung
09:24-09:36	Statistical Analysis for Initial Wind Characteristics in Southern Region of Myanmar by Ni Ni Moe Kyaw
09:36-09:48	Application of Support Vector Regression for Solar Power Predication by Narakorn Songkittirote
09:48-10:00	Semi-Transparent Photovoltaic Window Louvers for Building Integration Application by Phetdavanh Ladthavong
10:00-10:12	Comparison of Biodiesel Synthesis via Transesterification by Using Homogeneous and Heterogeneous Catalyst by Ying Chusree
10:12-10:24	The Thermal Performance of the Novel Solar Collector Integrated with Phase Change Material by Bundarith Nhel
10:24-10:36	Development of Biogas Fermentation Tank for Organic Food Waste in Chiangmai Community by Chakriya Chanracha
10:36-10:48	The Combustion Characteristic of a Community-Scale Biomass Stove by Paitoon Laodee
10:48-11:00	Modelling of Cooling Load in Close-System Solar Greenhouse Under Thailand Climates Using TRNSYS by Thiri Shoon Wai

Time	Topic
11:00-11:12	Anaerobic Digestion of Starch Wastewater: The Long-term Monitoring by Zangta Sang
11:12-11:24	Rheological Characterization of Alternative Raw Materials for Biodiesel Synthesis by Siti Hartini Hamdan
11:24-11:36	Effect of Heat Pretreatment on Biogas Production from PLA Bioplastic and Food Waste by Natthida Yarangsri
11:36-11:48	Color and Organic Compounds Reduction in Biogas Effluent of Ethanol Industry by Adsorption Process by Thanyaporn Khunluang
11:48-12:00	Screening Mesophilic and Thermophilic Consortia for Polylactic Acid-Bioplastic Degradation by Weerapong Chouyplod
12:00-12:12	The Design and Development of Smart Farm with Environmental Analysis by Panupong Tanomkiet
12:12-13:00	Lunch Break
13:00-17:00	Site Visit: Chiang Mai City Tour by Tram and Chiang Mai Flower Festival at Suan Buak Haad Public Park (Optional)

Agenda The 1st International Conference on Smart Community Development in the Asia Pacific (iSCAP2020)

Asian Development College for Community Economy and Technology, Chiang Mai Rajabhat University

21st February 2020

Session 2: Sustainable Community Development in Social, Economics, and Environment
Session Chairs: Dr. Sulak Sumitsawan
Associate Professor Dr. Rina Patramanon

Room 2: adiCET Office

Time	Topic
09:00-09:12	Sustaining the Humanities – Syntax of the East the Context of Kuala Lumpur, Malaysia by Sucharita Srirangam
09:12-09:24	Development of Sustainable Urban Drainage System Using Stormwater Management Model (SWMM) by Min Hein Khant
09:24-09:36	A Comprehensive Review of Cooling Systems for Agricultural Greenhouse by Napassawan Khammayom
09:36-09:48	The Effect of Conventional Sugarcane Planting Periods on Soil Properties by Realfang Suanake
09:48-10:00	Bio Smart Farm Management for the Model Community by Antika Phetcharee
10:00-10:12	Financial Analysis of Urban Bamboo-Ponics Vertical Farm by Natthaya Paobanzao
10:12-10:24	The Comparison of Energy Management Criteria for Energy Efficiency Development in the School by Chuntisa Kessmanee
10:24-10:36	Investigation of Turbidity and TSS Removal from Leachate Landfill Via Electrocoagulation Process by Norilhamiah Yahya
10:36-10:48	Guidelines of Activity and Service Development to Promote the Well-Being Among the Elderly People in Wang Thong Sub-district, Wang Nuea District, Lampang Province by Ardchawin Jaikaew

Time	Topic
10:48-11:00	An Investigation into Factors Affecting Environmental Awareness of Primary School Children in Mon State, Myanmar by Su Chan Myae
11:00-11:12	Long Term Care Digital Innovation Platform: the Sustainable Preparing for Healthy Aging Society by Pariwat Luangsuwimol
11:12-11:24	Understanding Cultural Differences between Thai and United States Postgraduate Students by Kittiwan Sinthunava
11:24-11:36	Green Edible Building Facades Potential for Energy Saving by Pee Pocherd
11:36-11:48	Learning Organizational Factors of Travel Business Agencies in Chiang Mai Province by Patarasri Inkhao
11:48-13:00	Lunch Break
13:00-17:00	Site Visit: Chiang Mai City Tour by Tram and Chiang Mai Flower Festival at Suan Buak Haad Public Park (Optional)

Table of Contents

Page

Experimental Study on Strength of Concrete with Partial Replacement of Fine Aggregate with Brick Waste

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Abstract: This paper aims to the green concrete making process by using recycled materials to prevent incompetent quality and scarcity of natural sand and gravel in near future. It will also be effective to the prevention of negative impact on environment. In this paper, the wasted bricks are crushed down into the particle sizes of fine aggregates as substitution of natural sand in concrete making. The various percentages: 0%, 5%, 15% and 25% of brick powders are mixed in each four types of concrete specimens. After 28 days curing, the compressive and the tensile strengths of the concrete specimens with various percentages of brick powders are tested. The test results indicate that the concrete made with fine aggregates of wasted brick is despite strength is lower than conventional concrete with 100% composition of fine aggregates.

Keywords: Brick powder, fine aggregates, compressive strength, splitting tensile strength

1 INTRODUCTION

Within a decade, the demand to construct the infrastructures and buildings are rising significantly with continuous growth of population. The higher the demand of construction, the higher the consuming rate of natural resources for making concrete is inevitable. M.Usha Rani and J. Martina Jenifer (2016) stated that the manufacturing of concrete has been increased up to 11 billion metric tons annually and the composition of aggregates is the highest with the percentage of 70 – 75% including both fine and coarse aggregates and water comprises about 15% and the composition of cementation binder is around 10%. Non-renewable natural resources used in making concrete such as sand (fine aggregates) and gravel (coarse aggregates) are extracted from river bed and crushing stones.

The shortage of natural resources will trigger as long as construction process go on by consuming natural resources. Therefore, Engineers, technicians and scientists have been researching to fulfil the purpose that can be substituted with other materials in the place of conventional materials. The substituted materials are targeting to have the same properties as conventional materials in their use for new design and innovation (Zamir Irfan, Syed Zeeshan Shafi and Altaf Ahmad Bhat, 2017).

In the place of conventional materials, using wasted materials such as rubber, glasses and bricks are becoming an interest to prevent the environmental impact and to recycle the wasted materials. Therefore, within the recent years, many experimental processes and researches are undergone to develop the concrete making technology by using recycled waste materials namely “green concrete”.

Especially sand mining for fine aggregates has a greater impact on nature as sanding mining are dependent and extracts from riverbeds and flood plains. Sand mining for fine aggregates has been notorious as it can affect to the ecosystem of aquatic lives in rivers, degradation to river system, lessen river flows and depletion to the ground water system and so on.

On the other side, from the brick manufacturers in local, the waste of broken clay bricks becomes higher with the tremendous rate of brick production. Therefore, low prices and eco-friendly materials such as crushed bricks are becoming the interest as the substitution in the place of natural fine aggregates. The use of broken bricks in the place of natural sand for concrete mixture becomes considerable option to reduce not only the environmental impact due to sand extraction but also waste of broken bricks.

The aim and objective is to substitute the broken brick as fine aggregates in the place of natural sand to preserve the ecosystem and natural resources. The previous researches were processed and delivered by other researchers. In this research, the compressive strength and tensile strength test of concrete specimens with different percentage composition of brick powder are processed.

Dissimilar to the composition of brick powder percentage of previous researches, 5%, 15% and 25% of brick powders are mixed with natural fine aggregates in each type of concrete specimens. For each brick powder composition in concrete specimens, three trial concrete samples are tested to get the average result. As the research is the experimental base, the compressive and tensile strengths of concrete specimens are not likely to be same with other researches or expected outcomes. In this paper, the results from the concrete specimens are recorded and compared to the results of the conventional concrete. The standard deviation is also performed to evaluate how much the result is different from its mean value.

2 MANUSCRIPT PREPARATION

2.1 Concrete Mix Design

The concrete mix design for the concrete specimens is referred to ACI 211.1-91 that is applied to calculate the weight of required materials. Firstly, the concrete grade and slump value is determined. Grade 30 or 4350 psi is target strength of the concrete and design slump is 125 mm.

As the next step, water-cement ratio is determined by the targeted strength of concrete and as the target strength is 4350 psi in this research, water cement ratio of 0.536 is used. The required weight of concrete is calculated through dividing water weight by water-cement ratio. Then volume of coarse aggregates is determined by the finess modulus of sand and nominal maximum size of the coarse aggregates.

The volume of fine aggregates is determined by estimating the weight of fresh concrete and the nominal maximum sizes of aggregates. The required weight of cement, water and coarse aggregates are already defined except fine aggregates and thus differences between estimation of concrete weight and total weight of

cement, water and coarse aggregates deliver the required weight of fine aggregates.

Table 1: Approximate mixing water and air content requirements for different slumps and nominal maximum sizes of aggregates (American Institute of Concrete,1991).

Water, lb/yd³ of concrete for indicated nominal maximum sizes of aggregate								
Slump, in.	⅜ in.*	½ in.*	¾ in.*	1 in.*	1-½ in.*	2 in.*†	3 in.†‡	6 in.†‡
Non-air-entrained concrete								
1 to 2	350	335	315	300	275	260	220	190
3 to 4	385	365	340	325	300	285	245	210
6 to 7	410	385	360	340	315	300	270	—
More than 7*	—	—	—	—	—	—	—	—
Approximate amount of entrapped air in non-air-entrained concrete, percent	3	2.5	2	1.5	1	0.5	0.3	0.2

Table 2: Relationship between water-cement or water-cementitious materials ratio and compressive strength of concrete (American Institute of Concrete, 1991)

Compressive strength at 28 days, psi*	Water-cement ratio, by weight	
	Non-air-entrained concrete	Air-entrained concrete
6000	0.41	—
5000	0.48	0.40
4000	0.57	0.48
3000	0.68	0.59
2000	0.82	0.74

Table 3: Volume of coarse aggregate per unit of volume of concrete (American Institute of Concrete, 1991)

Nominal maximum size of aggregate, in.	Volume of oven-dry-rodded coarse aggregate* per unit volume of concrete for different fineness moduli of fine aggregate†			
	2.40	2.60	2.80	3.00
⅜	0.50	0.48	0.46	0.44
½	0.59	0.57	0.55	0.53
¾	0.66	0.64	0.62	0.60
1	0.71	0.69	0.67	0.65
1½	0.75	0.73	0.71	0.69
2	0.78	0.76	0.74	0.72
3	0.82	0.80	0.78	0.76
6	0.87	0.85	0.83	0.81

Table 4: First estimate of weight of fresh concrete (American Institute of Concrete, 1991)

Nominal maximum size of aggregate, in.	First estimate of concrete weight, lb/yd³*	
	Non-air-entrained concrete	Air-entrained concrete
⅜	3840	3710
½	3890	3760
¾	3960	3840
1	4010	3850
1½	4070	3910
2	4120	3950
3	4200	4040
6	4260	4110

2.2 Physical Properties of Cement

The physical properties of cement used for concrete mixing is analysed by the laboratory and the outcome results are acceptable by checking with BS EN-1:2000. As the physical properties test of cement, consistency percentage, penetration depth, initial setting time, soundness, 2 days and 28 days compressive strength of cement mortar prisms are carried on. The outcome result of physical properties of cement and standard of BS EN-1:2000 are tabulated and compared as shown below.

Table 5: Physical properties test of cement provided by the laboratory

Physical properties of cement	Laboratory test result	Standard of BS EN-2:1000
Consistency (%)	29	Penetration point between 4 mm and 8mm from the base of mould
Penetration (mm)	7	
Initial setting time (min)	105 min	≥ 60 min
Soundness	<1	≤ 10 mm
2 days compressive strength of cement mortar prisms	26.57 N/mm²	≥ 10 N/mm²
28 days compressive strength of cement mortar prisms	49.24 N/mm²	Between 42.5 N/mm² and 62.5 N/mm²

2.3 Sieve Analysis of Brick Powder

As the wasted bricks are used as the fine aggregates in the concrete, these broken bricks are able to be bought cheaper than normal bricks. Those broken bricks are manually grinded into fine powder. After the grinding process, brick powder is sieved According to specification E - 11 of ASTM C-33 to get the proposed size to mix with sand as fine aggregates in concrete mixing.

The percent passing of brick powder to use as fine aggregates is defined by current available sieve sizes as follow.

Table 6: Proposed percentage passing of brick powder with available sieve sizes

Sieve	Percent Mixing
4.75-mm (No.4)	5 %
2-mm (No.10)	45%
850- μm(No.20)	
425- μm(No.40)	50%
250- μm(No.60)	
106- μm(No.140)	
75- μm(No.200)	Remove

The brick powder which passes sieve No.4 takes only 5% as the particle size of brick is larger than the normal size of fine aggregates. The particle sizes of brick powder which passes sieve No.200 is removed because the particle sizes of brick powder is undersized and it can't be effective in strength gaining but absorbs extra water. After confirming the percent passing of brick powder, the compositions percent of brick powder as fine aggregates are defined for concrete mixing process.

Table 7: Four types of composited percentage of brick powder in concrete mixing

Composition	Cement (%)	Coarse aggregate (%)	Fine aggregates (%)	
			Brick powder (%)	Sand (%)
1	100	100	0	100
2	100	100	5	95
3	100	100	15	85
4	100	100	25	75

The cube mould is used for the concrete specimens of compression test and the cylindrical mould is used for the concrete specimens of splitting tensile test. The dimension of cylindrical moulds are having height of the diameter is 300 mm (12 inches) and the diameter is 150 mm (6 inches). The dimension of the cube moulds are 150mm (6 inches) x 150 mm (6 inches).

2.4 Compression Test

The compression and splitting tensile strength tests are performed after their curing days of 7 days, 14 days and 28 days respectively.

The concrete cube samples are positioned carefully centre to the lower plate of the machine. The loading is continuously applied without a shock until the cracks occur and the maximum strength of the concrete cube samples reach. Then the compressive strength of the concrete samples is displayed on the screen and it is noted.

Figure 1: Splitting Tensile Strength Test

Figure 2: Description of Compression Strength on Display

2.5 Compression Test Results of Concrete Specimens

Splitting tensile strength is tested by applying the compressive force along the longitudinal length of the cylindrical concrete samples. This compressive force loads tensile stress along the length of cylindrical concrete samples and tensile stress is induced to the samples rather than the compressive stress.

This method is mostly used in measuring the shear resistance of the structural light weight concrete by applying tensile stress to the cylindrical concrete sample. Before the test is started, the additional steel plate is placed on the compression machine which length is not shorter than the cylindrical concrete samples. Then the cylindrical concrete samples are placed on the steel plate and align and centre of the upper compression plate.

The load is applied without a shock continuously within the range of 100 to 200 psi per minute. The load is applied until the failure of the cylindrical mould occurs. After the failure, the maximum applied load to the concrete samples and failure pattern is recorded. Then the splitting tensile strength for the concrete sample is calculated by the following equation described by American Society of Testing Materials (2004).

Figure 3: Splitting Tensile Strength Test

After the loaded force is collected the following equation is used to drive out the tensile strength of the concrete specimens.

$$\text{Tensile strength} = 2P/\pi LD \qquad (1)$$

When, P = Maximum applied load described by the testing machine
L = Length of cylinder
D = Diameter of cylinder

3 RESULT AND DISCUSSION

3.1 Compression Test Results of Concrete Specimens

According the description of the Figure (3.1), 7 days compressive strength of concrete samples with 15 % composition of brick powder shows the highest value out of other concrete samples with 0%, 5%, 15%, 25% and its highest average value is 16.18 N/mm^2 while conventional concrete is 14.34 N/mm^2, concrete samples with 5 % and 25% composition of brick powders are 15.06 N/mm^2 and 13.85 N/mm^2 respectively.

The compressive strength of all concrete samples results in higher strength results than 7 days compressive strength test results. The compressive strength of concrete samples with natural sands rises significantly over two times of 7 days compressive strength and the average value of 14 days and 7 days test results of concrete samples with 0% brick powder are 34.81 N/mm^2 and 14.34 N/mm^2 respectively.

Even though the concrete samples with different composition of brick powder also increase in strength than 7 days results, the strength gaining rate is relatively slower compared to conventional concrete test results.

The average compressive strengths of 5%, 15 % and 25 % compositions of brick powder in concrete specimens after 14 curing days are 27.89 N/mm^2, 19.66 N/mm^2 and 17.71 N/mm^2 respectively.

As more percentage of brick powder in concrete samples acquire, the ability of water absorption rate is higher than that of conventional concrete. Thus although the compressive strengths of 15 % and 25 % content of brick powder in concrete samples are higher than previous 14 days test results, the strength gaining rate is becoming slower and failed to reach 28 days target strength of 30 N/mm^2.

According to the compressive strength results of 28 days curing concrete samples, the concrete with 5 % composition of brick powder is the optimum rate that should be comprised in concrete mix design.

3.2 Splitting Tensile Strength Test Results of Concrete Specimens

As shown in Figure (4), The splitting tensile strength of concrete sample with 5% of brick powder composition in natural sand shows the highest value of above of all other concrete samples' strength after the strength test of 7 curing days.

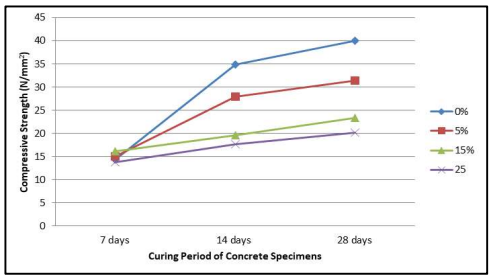

Figure 4: Compressive Strength of Concrete Specimens of 7 Days, 14 Days and 28 Days Curing Period

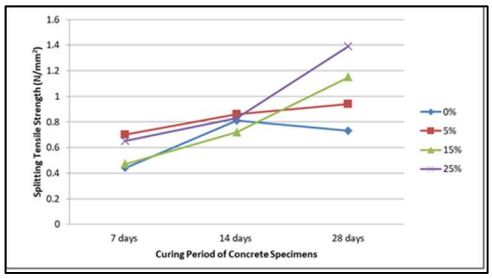

Figure 5: Splitting Tensile Strength of Concrete Specimens of 7 Days, 14 Days and 28 Days Curing Period

The average value of concrete specimens with 5% composition of brick powder is 0.70 N/mm^2. The lowest value is resulted in conventional concrete and its value is 0.44 N/mm^2. Concrete samples with 15% and 25% composition of brick powder results in average splitting tensile strength result of 0.47 N/mm^2 and 0.65 N/mm^2 respectively.

Comparing to 7 days splitting tensile strength results, 14 days splitting tensile result of conventional concrete is increased sharply up to almost double of 7 days splitting tensile strength results and 14 days splitting tensile strength of conventional concrete is 0.81 N/mm^2.The splitting tensile strength of concrete samples with 15% and 25% composition of brick powder are 0.72 N/mm^2 and 0.83 N/mm^2. Concrete samples with 5% content of brick powder is still the highest value among other concrete samples with brick powder compositions as the same to the previous 7 days strength test and its value is 0.86 N/mm^2.

Different to the previous splitting test results as shown in Figure (3.2), the concrete samples with 25% composition of brick powder is becoming the highest in splitting tensile strength in 28 days strength test. Its splitting tensile strength is 1.39 N/mm^2 while the concrete specimens mixed with 5% and 15% of brick powders are 0.94 N/mm^2 and 1.15 N/mm^2 respectively. The splitting tensile strength of conventional concrete is the lowest in 28 days strength test and its tensile strength is 0.73 N/mm^2.

3.3 Overall Discussion

As to data analysis based on the compressive strength tests of concrete specimens, Concrete specimens with natural fine aggregates doesn't gain strength test in 7 days compression test as the natural sand as fine aggregates used in concrete has less water absorption than brick powder. In 14 days test results, the concrete samples with 100 % natural sand shows significant strength uprising over 2 times of previous test result.

As though concrete specimens with 0% brick powder gain in strength significantly, other concrete samples with different compositions of brick powder results in slow compressive strength increasing. The strength gaining of concrete specimens with brick powders is dependent on the particle sizes of brick powders and composition percentages.

The smaller particles sizes of brick powders in concrete specimens acquire more water absorption and lower strength gaining. As the result of the analysis mentioned above, the more brick powder composition is higher in concrete samples, the strength increasing rate is slower and the concrete with 5 % composition of brick powder obtains the highest value in compressive strength among concrete samples with other different percentage compositions of brick powder except conventional concrete.

At 28 days compressive strength test, the conventional concrete gains more strength than its target strength of 30 N/mm^2. Then concrete samples with the least brick powder composition, 5 % also reach its target strength. The concrete samples with 5% brick powder is lower than conventional concrete in compressive strength because water absorption rate of brick powder is higher than natural sand and hardness of brick powder is lower than natural sand. However, the concrete with 15 % and 25% composition of brick powder are unable to reach the target strength of 30N/mm^2 as their strength gaining rate is becoming slower.

In 7 days of splitting tensile strength test, the conventional concrete with 100 % natural aggregates shows the lowest value in splitting tensile strength and it is expected result. The concrete specimen with 5 % composition of brick powder shows the optimum values than other concrete specimens including conventional concrete.

All of the splitting tensile strength of the concrete specimens increases significantly in 14 days test. The splitting tensile strength of the concrete samples with 5% of brick powder is highest and concrete samples with 25 % is the second highest of all other concrete samples. The tensile strength gaining rate of conventional concrete is the most significant as long as it is cured by immersing in water.

Therefore, at 28 days splitting tensile result, the concrete with 25% composition of brick powder shows the highest results out of all other results and the conventional concrete shows the

lowest result in splitting tensile strength. During the compression and tensile splitting test of the concrete samples, the deviation and irregular strength changes occur. Those errors are unpredictable and the possibility is decided by the crack patterns and composition of coarse aggregates. The irregular strength change in compression occurs due to tensile effects in concrete samples as shown below.

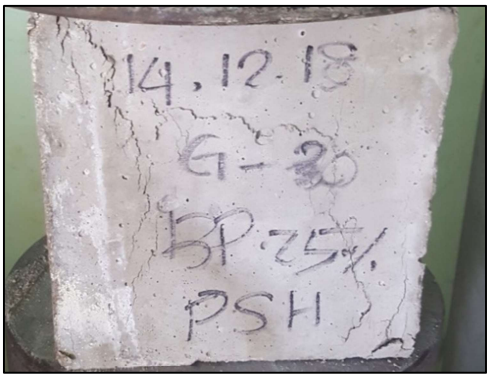

Figure 5: Tensile effects concrete samples

The irregular strength change in tensile strength occurs due to the particle sizes of coarse aggregates. The concrete sample with large particle sizes of coarse aggregates and brick powder especially changes the results of splitting tensile strength as shown in Figure (6).

Figure 6: The composition of coarse aggregates and brick powder differences in concrete samples

3.4 Standard Deviation

After the results of concrete samples are analysed, the standard deviation for each type of concrete samples are performed. The standard deviation is performed for the average value of three samples of concrete specimens with brick powder with different ratios 0%, 5%, 15% and 25% respectively. The standard deviation is calculated to evaluate the error bars graph.

Through the error bars graph with the standard deviation, the result deviation from its respective mean value or average value can be checked. The standard deviation for the compressive strength and splitting tensile strength of concrete specimens with different brick powders proportion are described in Appendix (3) and (4). The error bar graphs for the compressive strength and splitting tensile strength of concrete specimens with different brick powders proportion are described in Appendix (5) and (6).

According to the data analysis, the higher rate of standard deviation is found out in 14 days compressive strength result of concrete specimens with 0% brick powder and in 7 days compressive strength result of concrete specimens with 5% brick powder.

4 CONCLUSIONS

The main aim of this dissertation is to reduce the environmental impact due to the extraction of sand for construction purpose from river bed and send mining. To tackle the problem of over extracting of sand as fine aggregates in concrete mixing, the brick powder from brick waste is considered to replace in the place of sand in concrete mixing.

Then adoption of broken bricks becomes an option to innovate to use as fine aggregates in concrete mixing. Therefore, this paper is focus on the optimal percentages of brick powder in concrete that can be practically used in construction environment and adapted as green concrete. To fulfil this purpose, the compressive and splitting tensile strength of concretes with different composition percentage of brick powder as fine aggregates is analysed.

An overall consideration of results, the concrete samples with 5 % composition of brick powder is the most suitable composition for compressive strength of concrete. This result is gained by the lowest brick powder composition in concrete. According to other literature review, optimum composition of brick powder compared to previous research is different that is most of all other previous papers suggests 20% brick powder composition in concrete is the optimum results for both compressive and tensile strength. The deviation can occur due to the properties of materials and compositions of particles sizes of brick powder.

The composition of concrete samples with 5% of brick powder is available to use in practical construction site as its 28 days strength meet the target strength of 30 N/mm^2. The result can provide to use brick powder as fine aggregates in concrete mixing as the particle sizes and mixing percentages are analysed and recorded. With the designated mixing percentages depending on the particles sizes of brick powder, the concrete grade with 30 N/mm^2 can be practically casted with brick powder and used in practical.

By using the brick powder from brick waste in the place of natural fine aggregates will invent the problem of scarcity of premium quality of sand can be settled down to the certain percentage if the construction companies attempts to use brick powder in the place of sand with the percentage and particle sizes delivered by this paper. The composition of 5% of brick powder in concrete will deliver the optimum value in compressive strength than other percentage composition of brick powder.

Moreover, the composed percentage of brick powder is achieved by the certain particles of sizes of brick powder that is done by sieve analysis and changes in water –cement ratio.

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APPENDIX

7 Days Compressive Strength of Concrete Specimens (N/mm^2)

Item	Brick Powder	Trial Mix (1)	Trial Mix (2)	Trial Mix (3)	Average Result
1	0%	13.49	14.69	14.83	14.34
2	5%	14.47	14.2	16.52	15.06
3	15%	15.75	16.16	16.64	16.18
4	25%	13.94	13.88	13.74	13.85

14 Days Compressive Strength of Concrete Specimens (N/mm^2)

Item	Brick Powder	Trial Mix (1)	Trial Mix (2)	Trial Mix (3)	Average Result
1	0%	35.11	38.88	30.45	34.81
2	5%	27.91	27.84	27.91	27.89
3	15%	18.45	20.43	20.11	19.66
4	25%	17.93	17.9	17.3	17.71

28 Days Compressive Strength of Concrete Specimens (N/mm^2)

Item	Brick Powder	Trial Mix (1)	Trial Mix (2)	Trial Mix (3)	Average Result
1	0%	39.25	40.25	40.72	40.07
2	5%	30.61	31.73	31.45	31.26
3	15%	23.4	22.17	24.55	23.37
4	25%	20.82	20.05	19.8	20.22

Appendix (1) Compressive Strength of Concrete Specimens with Related Curing Days

7 Days Splitting Tensile Strength of Concrete Specimens (N/mm^2)

Item	Brick Powder	Trial Mix (1)	Trial Mix (2)	Trial Mix (3)	Average Result
1	0%	0.76	0.28	0.28	0.44
2	5%	0.72	0.76	0.62	0.7
3	15%	0.35	0.49	0.56	0.47
4	25%	0.89	0.56	0.49	0.65

14 Days Splitting Tensile Strength of Concrete Specimens (N/mm^2)

Item	Brick Powder	Trial Mix (1)	Trial Mix (2)	Trial Mix (3)	Average Result
1	0%	0.62	0.62	1.18	0.81
2	5%	0.69	0.56	1.32	0.86
3	15%	0.69	0.56	0.9	0.72
4	25%	0.69	0.62	1.18	0.83

28 Days Splitting Tensile Strength of Concrete Specimens (N/mm^2)

Item	Brick Powder	Trial Mix (1)	Trial Mix (2)	Trial Mix (3)	Average Result
1	0%	0.5	0.78	0.92	0.73
2	5%	1.2	0.92	0.71	0.94
3	15%	0.99	1.27	1.2	1.15
4	25%	1.41	1.34	1.41	1.39

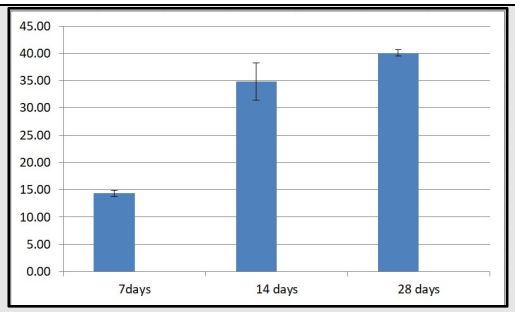
Appendix (2) Splitting Tensile Strength of Concrete Specimens with Related Curing Days

Compressive Strength of Concrete Specimens with 0% Brick Powder (N/mm2)					
Curing Day	Trial Mix (1)	Trial Mix (2)	Trial Mix (3)	Average Strength	Standard Deviation
7days	13.49	14.69	14.83	14.34	0.6
14 days	35.11	38.88	30.45	34.81	3.4
28 days	39.25	40.25	40.72	40.07	0.6
Compressive Strength of Concrete Specimens with 5% Brick Powder (N/mm2)					
Curing Day	Trial Mix (1)	Trial Mix (2)	Trial Mix (3)	Average Strength	Standard Deviation
7days	14.47	14.2	16.52	15.06	1.0
14 days	27.91	27.84	27.91	27.89	0.0
28 days	30.61	31.73	31.45	31.26	0.5
Compressive Strength of Concrete Specimens with 15% Brick Powder (N/mm2)					
Curing Day	Trial Mix (1)	Trial Mix (2)	Trial Mix (3)	Average Strength	Standard Deviation
7days	15.75	16.16	16.64	16.18	0.4
14 days	18.45	20.43	20.11	19.66	0.9
28 days	17.93	17.9	17.3	17.71	0.3
Compressive Strength of Concrete Specimens with 25% Brick Powder (N/mm2)					
Curing Day	Trial Mix (1)	Trial Mix (2)	Trial Mix (3)	Average Strength	Standard Deviation
7days	13.94	13.88	13.74	13.85	0.1
14 days	17.93	17.9	17.3	17.71	0.3
28 days	20.82	20.05	19.8	20.22	0.4

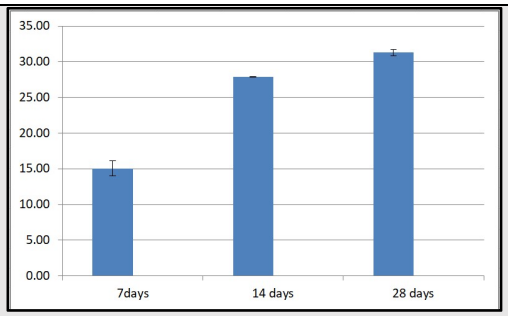
Appendix (3) Standard Deviation of Compressive Strength of Concrete Specimens with Related Curing Days

Splitting Tensile Strength of Concrete Specimens with 0% Brick Powder (N/mm2)					
Curing Day	Trial Mix (1)	Trial Mix (2)	Trial Mix (3)	Average Strength	Standard Deviation
7days	0.76	0.28	0.28	0.44	0.2
14 days	0.62	0.62	1.18	0.81	0.3
28 days	0.5	0.78	0.92	0.73	0.2
Splitting Tensile Strength of Concrete Specimens with 5% Brick Powder (N/mm2)					
Curing Day	Trial Mix (1)	Trial Mix (2)	Trial Mix (3)	Average Strength	Standard Deviation
7days	0.72	0.76	0.62	0.70	0.1
14 days	0.69	0.56	1.32	0.86	0.3
28 days	1.2	0.92	0.71	0.94	0.2
Splitting Tensile Strength of Concrete Specimens with 15% Brick Powder (N/mm2)					
Curing Day	Trial Mix (1)	Trial Mix (2)	Trial Mix (3)	Average Strength	Standard Deviation
7days	0.35	0.49	0.56	0.47	0.1
14 days	0.69	0.56	0.9	0.72	0.1
28 days	0.99	1.27	1.2	1.15	0.1
Splitting Tensile Strength of Concrete Specimens with 25% Brick Powder (N/mm2)					
Curing Day	Trial Mix (1)	Trial Mix (2)	Trial Mix (3)	Average Strength	Standard Deviation
7days	0.89	0.56	0.49	0.65	0.2
14 days	0.69	0.62	1.18	0.83	0.2
28 days	1.41	1.34	1.41	1.39	0.0

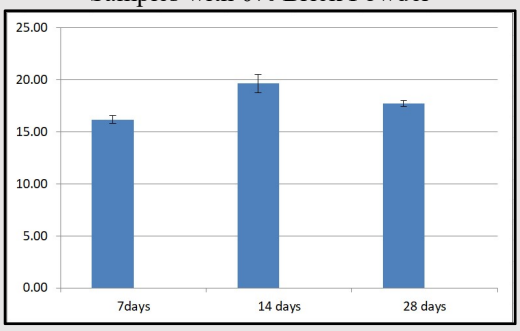
Appendix (4) Standard Deviation of Tensile Strength of Concrete Specimens with Related Curing Days



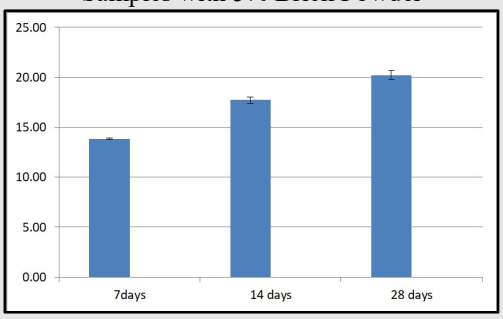
Compressive Strength of Concrete Samples with 0% Brick Powder



Compressive Strength of Concrete Samples with 5% Brick Powder

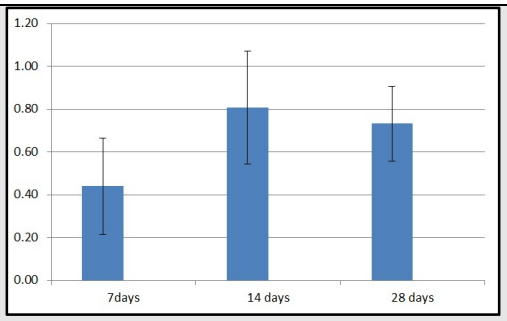


Compressive Strength of Concrete Samples with 15% Brick Powder

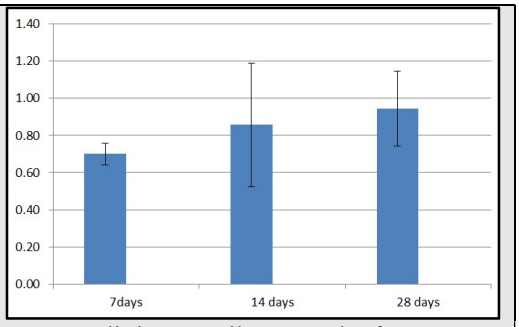


Compressive Strength of Concrete Samples with 25% Brick Powder

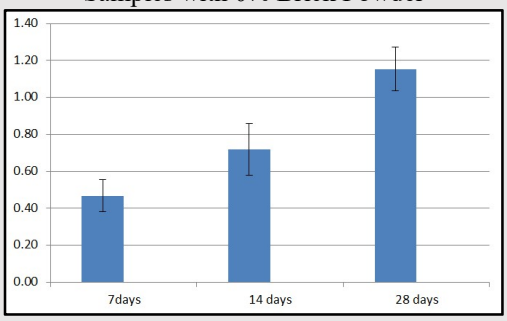
Appendix (5) Standard Deviation with Error Bars for Compressive Strength of Each of Concrete Samples with Various Proportion of Brick Powder



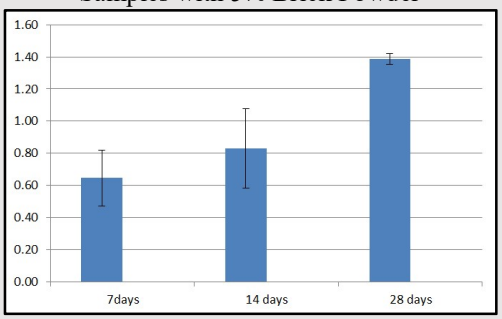
Splitting Tensile Strength of Concrete Samples with 0% Brick Powder



Splitting Tensile Strength of Concrete Samples with 5% Brick Powder



Splitting Tensile Strength of Concrete Samples with 15% Brick Powder



Splitting Tensile Strength of Concrete Samples with 25% Brick Powder

Appendix (6) Standard Deviation with Error Bars for Splitting Tensile Strength of Each of Concrete Samples with Various Proportion of Brick Powder

Estimation of Runoff Potential in Sittaung River Basin Using GIS Application

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Abstract: In planning of hydropower plants, optical usages of reservoirs, organizing for physical features of rivers and potential flood risks, surface runoff issue is a critical factor for those dramatic hydrological challenges. In this research, Sittaung river basin, known as the fourth biggest river in Myanmar, is chosen for case study. Then, the runoff potential of Sittaung river basin is estimated using SCS-CN method with the conduction of GIS application. Moreover, essential parameters namely land cover, Digital Elevation Model, soil type, rainfall, and hydrologic soil groups are considered. DEM is downloaded from the source of HydroSHED with SRTM 3 arc-second resolution with approximately 30m cell size by using Quantum GIS (QGIS) and is applied to define the basin for the proposed area. In addition, land use is prepared by using the satellite image of Servir Mekhoung Land Cover portal to justify the land cover behavior. Furthermore, soil map is also generated from the satellite image of Food and Agriculture Organization (FAO) to classify the hydrological soil groups which affect to the runoff potential. Another parameter called daily rainfall is downloaded from Tropical Rainfall Measuring Mission satellite to obtain the average rainfall data for the entire basin. And then, when runoff potential is estimated by integrating those layers with SCS-CN method in GIS application, the runoff depth is found to be maximum in the central part of the basin and is also found along the main stream, tributes and outlet point. Moreover, the uppermost and lowermost part of basin is seen to be lower value of runoff depth. In the area of high runoff depth, it is better for planning water resources projects such as hydropower generating, water control strategies, for example, reservoir, whereas the area with low runoff depth is found the highest infiltration rate.

Keywords: Runoff Potential, SCS-CN Method, Satellite Images Dataset, GIS Application, Sittaung River Basin.

1 INTRODUCTION

Myanmar or Burma is known as the Republic of the Union of Myanmar and a member of ASEAN.

The weather is tropical with monsoonal causing landslide and flooding during the rainy season. Myanmar has 52 million of population. The whole country is divided into five geology-regions namely, the eastern plateau, low lands, the northern mountain ranges, the central basin and the western ranges, and, the coastal broads. Moreover, Myanmar involves four main rivers in terms of Ayeyarwaddy River, Sittaung River, Thanlwin River and Chindwin River which are freely flow from south to north.

There are four major factors influencing runoff potential of a basin and which can be widely distinguished in term of storm characteristic, meteorological characteristics, basin characteristics and storage characteristics (Rajhunath, 2006). Surface runoff or discharge indicates that all water flowing over the ground surface with various forms of channel flow in gullies, rills, streams, or rivers and overland sheet flow. Surface runoff is simultaneous process of flowing from high elevation to low elevation with the action of gravitational forces. By combining the small stream, the larger stream network is formed and eventually freely flow into the river. From that it moves forward into the ocean and ending the whole hydrological cycle (Mishra and Singh, 2003). Rainfall or precipitation event is critical in determining the runoff potential with its occurrence and quantity of rainfall characteristics.

Other factors known as land cover type, soil profile type, slope, rainfall intensity, catchment shape, rainfall duration and area of the catchments also have direct impact on runoff volume. To evaluate the runoff potential, the conduction of GIS serves as a bridge and interrelation with other data which are key factor of runoff depth.

In this research, the primary parameters namely slope, soil type, land cover, rainfall, basin area are taken into account and those parameters will be generated from GIS application. The generated parameter layers are integrated and determined the surface runoff potential with the overlay analysis technique.

1.1 Aim and Objective

The study target is to predict the surface runoff potential by using Soil Conservation Service-Curve Number Method with the conduction of GIS application.

The primary objectives of this research are to develop the Digital Elevation Model (DEM) from global satellite product for extracting basin shape, to generate basin Soil Map, and Land cover map for Sittaung River Basin from the Satellite data image with GIS application and to study the usage of Satellite rainfall data set, from TRMM satellite data provider for the study area.

1.2 Study Area

For this research, Sittaung River Basin will be studied among four main rivers in Myanmar. Sittaung is the fourth biggest River basin in Myanmar which is essential for farming and food production representing 40 percent of the country's total national output, and it also behaves as the middle networking system for the transport framework system interfacing the seven regions and seven states of the nation. The location of the River basin situates at latitude 16°57′54"N and Longitude 96°59'15"E "The Sittaung River basin is situated in central-southern parts of Myanmar and involving Sittaung River. Sittaung River rises from the northeast of Yamethin and on the edge of the Plateau of Shan. The flow direction of river is start from Southern part of the basin to the Gulf of Martaban of the Andaman Sea with 420 kilometres. There are 23 major tributes which flowing to the Sittaung River Basin. The total catchment area is 48100 square meters. Between the forest cover Bago mountain ranges located to the west and the high elevated Shan Plateau situated on the east, the wide Sittaung River Valley is laid. The gross population of Sittaung River Basin is almost 5.8 million or 10% of Myanmar population. Bago and Taungoo regions are mostly cover the basin are, however, Kayin, Kayah, Shan, Mon States and Nay Pyi Taw Union are composed as a sector inside the basin. The major cities that involve inside basin are Naypyitaw, Yedashe, Taungoo, Phyu, and Theinzayat.

In respect to the climate condition, the atmosphere of the bowl is affected by the southwest rainstorm in summer, from May to October, and the upper east storm in winter, from

November to April. The average precipitation of Sittaung River Basin is 889mm in the northern part whereas 2540 mm to 3810 mm ranges in the southern part of the basin. The average temperature is variable within 24 to 29 ℃. In regard to the soil condition, the major soil layers are sandstones, clay and silt layer. In the western sector of the catchment of near the Bago basin, there is a well-drained soil layer with more than 30% of clay content. The agricultural category is the most influenced in this basin. (Nesheim et al., 2017)

The major problem currently facing in the Sittaung River Basin is flooding matter which is the most frequent occurred challenges for this river basin (Su Kyi, 2017). The above Figure 1 describes the location of Sittaung River Basin.

Figure 1: Location of Sittaung river basin.

1.3 Applied Data in this Study

Digital Elevation Model (DEM) was obtained from the Global DEM map of USGS (US Geological Survey) data provider with the void-filled elevation model of 3 Arc second global digital elevation model (30 meters) resolution with 1:50,000 scale by the link of (https://hydrosheds.cr.usgs.gov). The land cover map was prepared by downloading Global Land cover satellite image of the Servir Mekoung Land Cover Portal with the link of http://servir-rlcms.appspot.com/static/html/map.html. The soil profile map is developed from the Global satellite image of Food and Agriculture Organization (FAO) of the United State from the link of http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/en/.

2 METHODOLOGY

The materials applied in this study of essential parameters in term of Hydrologic soil groups, Land cover/use map, Digital Elevation Model, then daily rainfall data records. The land use, Digital Elevation Model (DEM), rainfall data and elevation will download from satellite image through GIS application. And then Hydrological Soil Groups (HSG) map will output depend on soil profile types, percentage slope and soil infiltration rate. After that combination of Hydrological Soil Groups and Land use map will produce Soil-Vegetation-Land use (SVL) complex and then will result runoff curve number (CN). After that using SCS-CN method, final runoff potential depth is evaluated.

In order to estimate the runoff potential for the study Sittaung River Basin, Soil Conservation Service Curve Number Method (SCS-CN) is applied. The fundamental equation is

$$Q = \frac{(P - I_a)^2}{P - I_a + S} \quad (1)$$

where,

P	=	total rainfall
I_a	=	initial abstraction (all losses before runoff starts)
F	=	cumulative infiltration excluding I_a
Q	=	direct runoff depth
S	=	Storage volume (inch)

In SCS-CN method, parameter S relies on the types of soil profile, antecedent moisture condition (AMC), land use/cover, and hydrological condition. Parameter Ia of initial abstraction means interception (short term losses), surface storage an infiltration (Hollander

and Hall, 2016). Firstly, storage volume (inch), S is firstly evaluated by the following equation.

$$S = \frac{1000}{CN} - 10 \quad (2)$$

Where,

S = Storage volume (inch)
CN = curve number

The CN values depend on land use, slope, soil type and variable in initial ground water content. The real curve is related to the storm rainfall percentage that flows as storm flow. According to experimental studies of small agricultural watershed in the United State, it recommends that the initial abstraction Ia might be estimated based on the below equation.

$$I_a = 0.2S \quad (3)$$

By substitution of this, the equation (4) will be as follow.

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \quad (4)$$

(Source: Davie, 2008)

2.1 Software Overview

The GIS is the most common useful tool and user-friendly open source desktop GIS. It gives numerous helpful capacities and highlights and their number is consistently developing. It provides an extensive variety of raster and vector designs and in addition to database, and OGC administration. A demonstrating or modelling design in a GIS gives an ideal environment. Such a methodology permits the capacity, integration, analysis, and support of extensive ecological information collections. Moreover, it gives a proficient, financially effective method that offers potential outcomes to research factors that impacts the rate of runoff over a vast region. The data accomplished can be utilized to simulate the impacts of specific choices on catchment administration practices to protect for example excessive runoff that may prompt various issues.

Among various utilization and development of GIS application in hydrological modelling, Quantum Geographic Information System (QGIS) is applied. QGIS application is free open source software which is most suitable for University Research because of its free cost. There are several approach parameters to represent the various parameters which is sensitive to surface runoff potential. Among those several parameters, land cover, soil type, slope, rainfall is considered as a sensitive parameter in this research. QGIS technique and satellite image datasets has been utilized to predict the spatial variation of hydrological parameters. They are the primary factors in evaluating runoff volume and set as input parameters to GIS.

The thematic layers involve land cover, soil type, rainfall and slope. The included points and polygons were changed to type of grid. The particular input layer of topicals reclassified based on their characteristic, physical properties, and its structure by allotting numbers ranging from 1 up to 5. These numbers are relied on the basic consideration for stage of likelihood of runoff potential to every classes for those sensitive layers. In this assigning the number, the higher number is defined as the high possibility of runoff volume and vice visa. After assigning to every layer into specific class types, the classified layer is integrated to evaluate with raster calculator analysis in QGIS environment in version (QGIS 2.18.26). Through this layer's analysis, the summation weight of latest cooperated grids was developed as the total of the weights allowed to the different classes for various layers.

Another issue to be discuss is that daily rainfall data download case. The available format to input QGIS is NEDcdf and csv file format. However, to evaluate the average rainfall for each station and spatial interpolation method for the whole basin, only csv file format is permitted by QGIS. On the other hand, the satellite rainfall data is only available in NEDcdf file type. To extract those downloaded NEDcdf file, another software known as ArcMap GIS software is compounded to complete estimating runoff. This is one of the obstacles of satellite rainfall data to extract csv file for the follow up procedures.

3 RESULT AND DISCUSSION

Runoff potential is happening within various hydrogeology environment. A systematic computation of runoff potential is very important for the proper management and utilization of this priceless natural resource. Thus, the cooperation of GIS (Geographic Information System) and satellite image datasets are essential tools and

techniques in surface hydrology research. In accordance with the methodology, with the integration of QGIS software, generating the map of Digital Elevation Model (DEM), Soil Profile Type, Land cover, then sub basin and rainfall map is prepared.

Following that, from the DEM map, basin shape is extracted. Classifying hydrologic soil groups is based on soil profile map. And then, identifying the runoff CN for hydrologic cover complex with respect to hydrologic condition is determined in according to land use/ land cover map. Following that, antecedent moisture conditions (AMC I, AMC II, AMC III) are discriminated by the volume of antecedent rainfall which is the summation of 5-day antecedent rainfall as API (antecedent precipitation index). In this research, 2017, Area-Averaged of Near-Real-Time Precipitation Rate daily 0.25 degree is applied which is reflected to soil moisture condition.

After resulting the required information from generated maps, direct runoff for entire basin is determined by using SCS-CN method.

3.1 Catchment Delineation

To determine the slope and how the elevation of ground surface changed with position of Sittaung River Basin, the Digital Elevation Model (DEM) map is critical element for basin slope presentation and which is a digital representation of terrain relief structure.

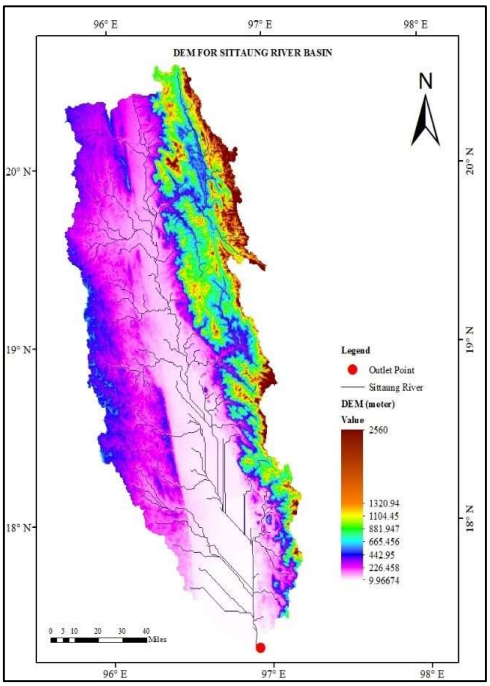

Figure 2: DEM map of Sittaung river basin.

In simulation runoff potential, slope plays a crucial issue which relies on the degree of slope of the topography. An area where has flat topography will definitely increase infiltration and less runoff potential while a steeply area gives high runoff potential with less infiltration.

Form the above Figure 2: DEM map, the eastern part of the basin is found the hill side with the highest elevation of above 615m whereas the basin in the western part is seen as the flat area with the slope of ranging from 52.18m to 279.9m. High runoff is occurred at the hill side compared to the flat area where would be the water retention area as a limit.

3.2 Land Cover

Land cover has highly control over runoff potential, evapotranspiration, identification and interpretation of land use pattern of research area which is prepared relied on satellite images and various land cover classes.

In accordance with the map of land cover Figure 3, six classes namely closed forest, opened forest, agriculture, grassland, urban and water body are generated. There was seen a minimal change within the period of fifteen years. The land cover map is from Servir Mekong Portal with 30 m cell size resolution with 2015 image.

The influence of grassland saw in the middle part of the basin and runoff value will be high infiltration rate. Moreover, the higher influence of opened forest with almost two-third of basin area saw in the Figure 3 and provide minimum value of runoff potential because of its high infiltration. Another land cover classification analysis, the small area influence of closed forest is only seen in the hilly region which have high runoff potential. Moreover, the coverage of urban land cover type is approximately about 20% of basin area that is registered as the highest runoff potential due to without infiltration.

3.3 Soil Profiles

Soil type dominant on the relationship between runoff and infiltration rates with the degree of permeability which is a primary factor in hydrogeology that examine the runoff potential. The formation of soil is based on the climate, geology physiographic, and other factors influence for soil development and formation. The soil class applied for the runoff potential are relied on the FAO's hydrologic properties.

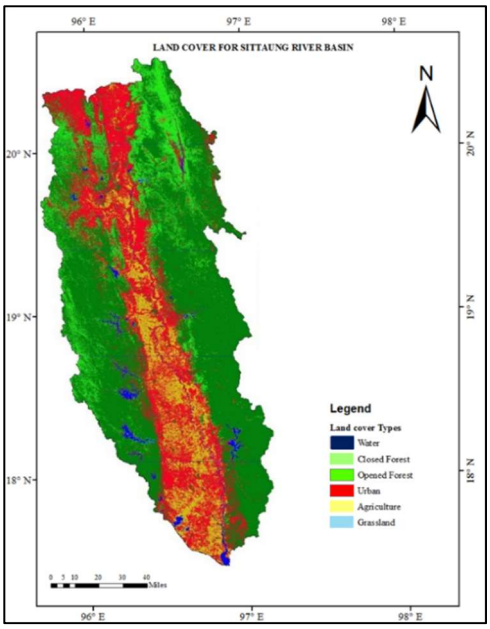

Figure 3: Reclassify land cover map for Sittaung river basin.

Soil texture classification is carried out based on Hydrologic property of FAO Classification of Soil FAO. In Figure 4: soil profile map, there are total of six different soil classes are resulted namely Gleysol, Eutric Gleysols, Orthic Acrisols, Chromic Cambisols, Chromic Luvisols and WAT. After that, those different soil texture are again distinguished by hydrologic soil group (HSG) by USDA soil classification which depends on infiltration rates. Finally, hydrologic soil groups are categorized by Table 1.

Inside basin, along the main stream network direction or middle part of the basin, there are Eutric Gleysols (clay) type placed which mean that the soil type of clay is saturated with ground water for long enough period. Moreover, the excessive wetness of shallow depth, no more than 50cm from the soil surface, there will be high runoff potential.

Another soil type of Dystric Nitosols is situated in the western part of the basin which have the lowest infiltration rate with 0.2 mm/hr and as a consequence, the high runoff potential is produced. The third most dominant of Orthic Acrisols is found in the eastern part of the basin. The soil texture type of loam is mostly found in the hilly region where is considered generation high runoff potential because of its topography with steeply slope and less amount of infiltration rate.

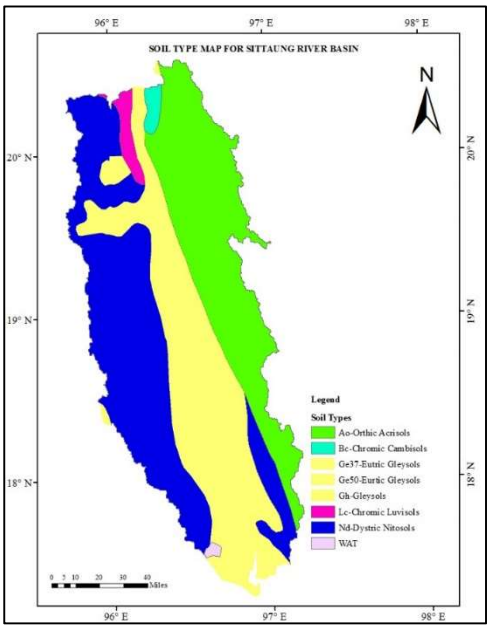

Figure 4: Soil profiles map of Sittaung river basin.

Table 1: Categorizing hydrologic soil groups (Soil Conservation Service, 1972)

FAO Soil	Soil Texture	Infiltration rate (in/hr)	HSG
Eutric Gleysols	Clay	0.06	D
Chromic Cambisol	Sandy Loam	0.8	A
Dystric Nitosols	Silt	0.2	B
Orthic Acrisols	Silty clay loam	0.06	B
Chromic Luvisols	Loam	0.3	B
WAT	Water	≤0.06	D

3.4 Rainfall

In order to estimate runoff potential, precipitation is the critical input data of hydrologic cycle (Jr and Gary, 2003). With a knowledge of rainfall nature and its characteristics, the upcoming process of runoff, evapotranspiration, and runoff are predicted. Because of that, in hydrological analyses, the areal rainfall distribution is main issue.

Although there are lots of areal precipitation estimation methods, Isohyetal method was applied to estimate areal precipitation for the entire basin. This estimation technique is commonly applied for averaging precipitation depths gathered at ground rain gauge station.

For a single station, the precipitation data was downloaded from the TRMM precipitation satellite data. After interpolating the daily rainfall data, Figure 5 average rainfall map for the entire basin is resulted. As for the discussion of generated rainfall map for this study area, 2017 TRMM Area Average Rainfall 3B42 RT is downloaded with Giovanni Satellite Data provider. From this daily rainfall record data, from May to October have oscillated rainfall pattern. The maximum daily rainfall is mostly in the 5/9/2107 to 4/7/2107.

However, with the Isohyetal method, the average rainfall data is produced by interpolation. The maximum rainfall depth is 14 mm in the middle part of the basin while the minimum rainfall depth is 6.32 mm which can be seen in the uppermost part of the basin.

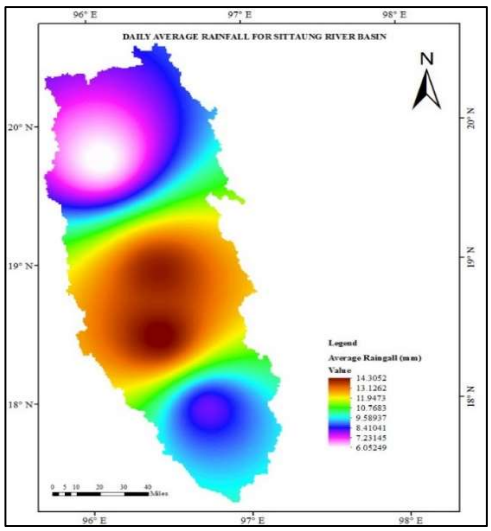

Figure 5: Daily average rainfall map for Sittaung river basin.

3.5 Curve Number Value

CN is simulated depend in the physical characteristics of the basin, land use, soil type, hydrological soil groups, hydrologic condition, precipitation and antecedent Soil moisture content. The resulted Sittaung River Basin for CN map is shown as Figure 6.

In accordance with the Figure 6, the statement of low curve number value of 65 means that water may easily infiltrate into the soil, with letting low rate of surface runoff. A high curve number value of 93 means that the water may infiltrate with the least amount of water instead turns into high runoff.

3.6 Runoff Potential Using SCS-CN Method

Soil Conservation Service Curve Number (SCS-CN) method considers primary runoff producing basin characteristics, such as soil type land use, and AMCs to evaluate runoff volume and losses. First of all, applying (Inverse Distance Weighted method) with interpolation tool and isohyetal method in QGIS, the maximum high

runoff curve number is simulated for every single polygon and the value of precipitation value in average is produced. From that step, potential maximum retention after runoff begin is evaluated with SCS-CN method. Figure 7 shows the resulted map of runoff potential depth for the Sittaung River Basin.

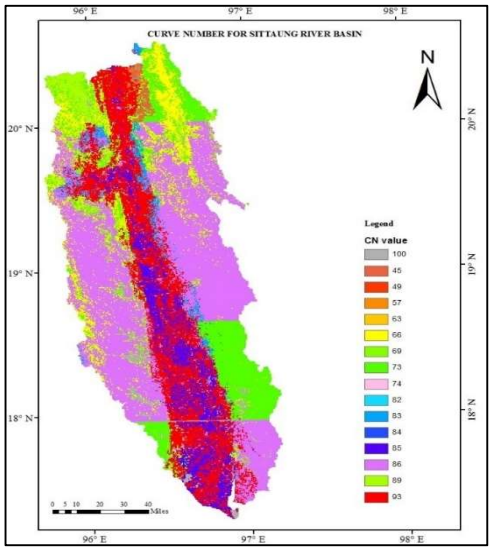

Figure 6: Curve number value for Sittaung river basin.

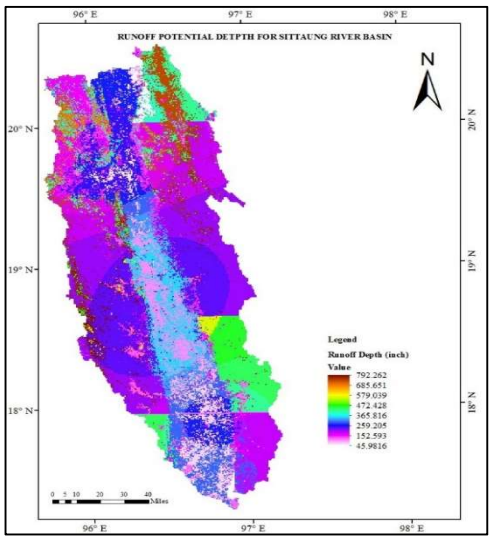

Figure 7: Runoff potential depth for Sittaung River Basin

In resulted map, the maximum runoff potential depth is found in the centre part of the basin with above 259.205 mm in term of percentage almost 25% of basin area because where is also the place of highest rainfall depth and locating Eutric Gleysols (clay) having least infiltration. Moreover, the peak runoff potential value is seen at the hilly region with 792.262 mm with minimum infiltration rate and it leads to the highest runoff depth. To say more, along the main stream and tributes, runoff potential is found 365.816 mm to 259.205 mm.

Another point is that opened forest area is seen to be the fourth maximum runoff depth with 472.48 mm. In most area of this high runoff potential depth coverage is Eutric Geleysol (clay) type with low permeability or infiltration rate of hydrological soil group D and lastly produced the high curve number which means that the higher storage volume in the Sittaung River is less and thus the possibility of flooding will be great.

4 CONSLUSIONS

In this research, runoff potential depth is estimated for the Sittaung River Basin by the conduction GIS application. The values for runoff potential depth are resulted for the entire basin by applying SCS-CN Method. By taking into account of the result of high runoff potential for two-third coverage of the basin, it may lead to the flooding event if not control the surface runoff volume.

Moreover, in this research, the future development structures in term of sub surface dyke, farm pond, percolation tanks and check dam are not taken into account for the water resource development of the basin. Therefore, from the result of high runoff potential inside basin, a necessary attempt is required to investigate whether or not Water Harvesting Structures (WHS) installation based on the generated land cover, soil map, slope, hydrological soil group and daily rainfall. Moreover, as a positive way, it is better to construct the hydro power plant to harvest the surface runoff and utilized in distribution of electricity and improvement of irrigation system inside basin.

This research supports the new challenging of hydrological problems. And also served as a bridge of linking topography, surface features related with runoff potential by conducting with GIS application. Moreover, it gives a thoroughly knowledge about downloading satellite data. A message of free download data related with earth topography data, geology data and meteorology data are available as desired.

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Statistical Analysis for Initial Wind Characteristics in Southern Region of Myanmar

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Abstract: Wind is one of the fastest growing and environmentally sustainable source of energy among all available renewable energy resources. Moreover, wind characteristics is one of the significant studies to determine the suitable sites for construction of infrastructures and of wind energy systems. The primary objective of this study is to analyze the wind characteristics of the selected stations. Seven meteological stations at Mon State and Tanintharyi Region which are located in southern region of Myanmar are selected in this study. Ten years of wind speed data measured at 10 m above ground level are obtained from Department of Metrology and Hydrology, Myanmar. Firstly, annual variations in wind speeds are analyzed by spatial wind mapping using ArcGIS 10.3.1 with Inverse Distance Weighted (IDW) interpolation. Then, wind speeds with different heights are extrapolated by power law. Statistical analysis of Weibull and Rayleigh distribution functions are applied to analyze the wind characteristics. Errors of the statistical analysis are computed by coefficient of determination (R^2) to find out the fitness of the distribution functions. From the spatial wind map, mean wind speeds of Thaton, Kyaikkhame and Kaw Thaung are 1 m/s or greater during the study period. From the wind profile, mean wind speeds at 100 m height of Thaton and Kaw Thaung are about 3 m/s or greater almost all years of the study period. From statistical analysis, for these two stations, Weibull shape factors of 6.64 and 6.54 while Rayleigh constant shape factor of 2 indicates that mean wind speeds of these stations give higher values and less annual wind speed variations. Besides, R^2 of these two stations tend to approach to one. Finally, it can be concluded that Thaton and Kaw Thaung are higher wind speed and more stable wind stations than any other stations in southern region of Myanmar.

Keywords: ArcGIS 10.3.1, IDW, power law, Weibull, Rayleigh, R^2

1 INTRODUCTION

The new generation of structures which is flexible, low in damping and light in weight generally exhibits an increased susceptibility to the action of wind. The performance of structures subjected to the action of wind will be adequate during their anticipated life from the standpoint of both structural safety and serviceability. Wind or the motion of air with respect to the surface of the earth, is fundamentally caused by variable solar heating of the earth's atmosphere. Temperature distribution in the atmosphere causes the production of winds. (Robert H, 1986) Myanmar is situated in the tropical climate region, a region that is highly vulnerable to impacts from changes in wind. Myanmar has many hilly regions in rural areas and coastal regions of about 1,930 kilometres (1,200 miles) strip facing to the Bay of Bengal and the Andaman Sea, which are the areas of highest wind potential. Moreover, Myanmar is situated at the northeast parts of the Bay of Bengal and north of Andaman Sea, so there are some of the weather disturbances such as cyclone, very destructive power to the coastal areas of landfall points, passage of western disturbances from the northeast India and easterly waves from Thailand and activity of Typhoon Remnants from the China Sea towards Myanmar; accentuate the aspect of local climate. Likewise, Myanmar has also clear evident of the abnormal climatic conditions mostly after 1980s. Severity and duration of this abnormal regional climatic pattern strongly influence the climate of Myanmar. Thus, it is necessary to study the spatial wind mapping, wind profile and wind frequency for decision making and planning for various types of building systems of Myanmar. Thus, this study describes the stastical analysis of initial wind characteristics in southern region of Myanmar.

2 METHODOLOGIES

Inverse Distance Weighted (IDW) interpolation method is used to gain the wind map of the selected stations. Power law is used to calculate wind speed extrapolation with height. Weibull distribution and Rayleigh distribution can be used to assess the wind frequency and the fitness of distribution function is determined by Root Mean Sqaure Error equation.

2.1 INVERSE DISTANCE WEIGHTED (IDW) INTERPOLATION

Inverse Distance Weighted (IDW) interpolation method estimates an unknown value as the weighted average of its surrounding points, in which the weighted value is the inverse of the distance raised to a power. It is remembered that the search distance or number of closest points determines how many points will be used.

$$z_u = \frac{\sum_{i=1}^{s}\left(\frac{z_i}{d_{iu}^k}\right)}{\sum_{i=1}^{s}\left(\frac{1}{d_{iu}^k}\right)} \tag{1}$$

where z_u is the unknown value of estimated at u; z_i is the attribute value at control point i; d_{iu} is the distance between points i and u; s is the number of control points used in estimating and k is a factor.

Spatial autocorrelation is the underlying assumption of Inverse Distance Weighting.

2.2 Wind Speed Extrapolation

The wind profile power law is a relationship between the wind speeds at one height, and those at another. Power law is the most common yet simple empirical expression for the extrapolation wind speed to the desired height. The wind profile power law relationship is:

$$\frac{u}{u_T} = \left(\frac{z}{z_T}\right)^{\alpha} \tag{2}$$

where u is the wind speed (in metres per second) at height z (in metres); and u_T is the known wind speed at a reference height z_T. The exponent (α) is an empirically derived coefficient that varies dependent upon the stability of the atmosphere. The value of 1/7 for α is commonly assumed to be constant in wind resource assessments, because the differences between the two levels are not usually so great as to introduce substantial errors into the estimates (usually < 50 m). Even under neutral stability conditions, an exponent of 0.11 is more appropriate over open

water (e.g., for offshore wind farms), than 0.143, which is more applicable over open land surfaces.

Provided there are no significant ground level obstacles, the friction coefficient α is set empirically and the equation can be used to adjust the data reasonably well in the range of 10 up to 100-150 metres. The coefficient varies with the height, hour of the day, time of the year, land features, wind speeds and temperature. All such findings have emerged from the analysis undertaken at several locations worldwide (Farrugia, 2003; Jaramillo & Borja, 2004; Rehman, 2007). Table 1 shows the friction coefficients of various land spots that, in each case, are given in function of the land roughness (Fernández, 2008; Masters, 2004; Patel, 2006).

Table 1: Friction coefficient, α

Landscape type	α
Lakes, ocean and smooth hard ground	0.10
Grasslands (ground level)	0.15
Tall crops, hedges and shrubs	0.20
Heavily forested land	0.25
Small town with some trees and shrubs	0.30
City areas with high rise buildings	0.40

2.3 Statistical Analysis

As wind speed changes regularly, frequency distribution of wind speed based on time series data can be calculated. Exact probability density function describing the speed data is difficult to find. Researches have shown that Weibull function and Rayleigh function fit the wind probability distribution more accurately compared to others. (Ayush P, 2016)

2.3.1 Weibull Distribution

Naturally, the wind's speed constantly varies. It is necessary to know exactly how often the wind blows how strongly. Weibull distribution is a significant tool to estimate to express the wind speed frequency distribution of a particular location. Weibull is a two parameter distribution function and is represented by a dimensionless shape parameter k and scale parameter c in units of wind speed (m/s) and it can be described by its probability density function f (v) of observing wind speed v as given below:

$$f(v) = \frac{k}{c}\left(\frac{v}{c}\right)^{k-1} e^{\left[-\left(\frac{v}{c}\right)^{k}\right]}, (k > 0, v > 0, c > 1) \quad (3)$$

where v is the wind speed. For calculating the parameters of Weibull distribution, empirical method of Justus and Lysen (P. K. Chaurasiya, 2018) are used in this study which is discussed below.

$$k = \left(\frac{\sigma}{\bar{v}}\right)^{-1.086} \quad (4)$$

$$c = \frac{\bar{v}}{\Gamma\left(1+\frac{1}{k}\right)} \quad (5)$$

The change of k makes a great impact on the distribution curve. If $0 < k < 1$, the mode of distribution is zero and the distribution density is the decreasing function of x; if $k = 1$, the Weibull distribution is identical to the exponential distribution; if $k = 2$, the Weibull distribution is identical to the Rayleigh distribution; if $k = 3.5$, the Weibull distribution approximates the normal distribution. (Guojie, 2016) In moment method of Justus and Mikhail (P. K. Chaurasiya, 2018), mean wind speed $\bar{v}$ and standard deviation (σ) are as follow:

$$\bar{v} = \frac{1}{n}\sum_{i=1}^{n} v_i \quad (6)$$

$$\sigma = \left[\frac{1}{n-1}\sum_{i=1}^{n}(v_i - \bar{v})^2\right]^{0.5} \quad (7)$$

Weibull parameters c and k, characterize the wind potential of the region under study. Basically, the scale parameter, c, indicates how 'windy' a wind location under consideration is, whereas the shape parameter, k, indicates how peaked the wind distribution is. (M. Z. Ibrahim, 2014) The Weibull scale parameter, c, is in m/s; a measure for the characteristic wind speed of the distribution. A small value for shape parameter k signifies very variable winds, while constant winds are characterized by a larger k.

2.3.2 Rayleigh Distribution

Rayleigh function is special case of Weibull function. When shape parameter $k = 2$, Weibull distribution becomes Rayleigh distribution. (Mehr G, 2019)

$$f(v) = \left(\frac{2v}{c^2}\right) e^{\left[-\left(\frac{v}{c}\right)^2\right]}, (k > 0, v > 0, c > 1) \qquad (8)$$

where v is the wind speed and scale parameter, c is calculated the same as in Weibull distribution.

2.4 STATISTICAL ERROR ANALYSIS

In order to check how accurately a theoretical probability density function fits with observation data, in this paper, statistical analysis error is considered as judgment criterion. To evaluate the performance of considered distribution, root mean coefficent of determiantion (R^2), is performed. The size of class intervals chosen in this study is 1 m/s.

$$R^2 = \frac{\sum_{i=1}^{n}(y_i - m)^2 - \sum_{i=1}^{n}(x_i - m)^2}{\sum_{i=1}^{n}(y_i - m)^2} \qquad (9)$$

where n, y_i, x_i and m represent observation count, actual i^{th} wind speed, predicted i^{th} wind speed and average wind speeds. The value for this error is positive and higher R^2 values will indicate a better fit. (Mehr G, 2019)

3 RESULTS AND DISCUSSIONS

An accurate determination of wind characteristics is taken into account of year to year variations of the wind conditions. Therefore, recorded data for ten years wind speed is considered to investigate wind characteristics of the selected stations.

3.1 Study Area

Location of Myanmar and southern region of Myanmar (study area) is shown in Figure 1. In the study area, seven stations are selected. Among seven selected stations, four selected stations are located in Mon State and three selected stations are located in Tanintharyi Region. Location of selected stations in study area is also shown in Figure 2. Wind speed data of the selected stations is analyzed to find out different wind characteristics of these stations.

Figure 1: Location of Myanmar and southern region of Myanmar (study area)

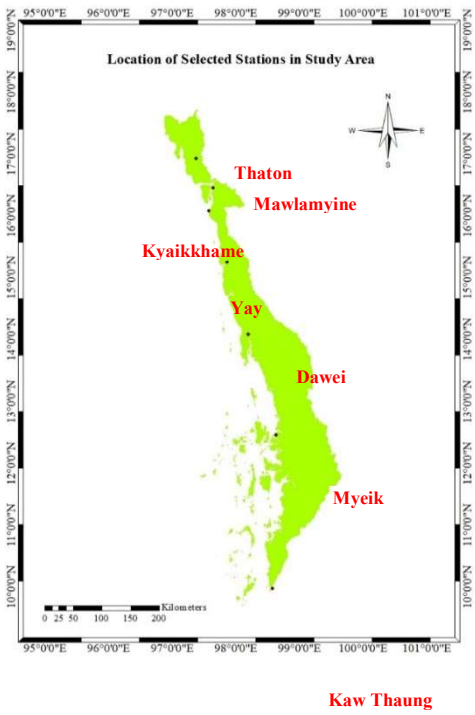

Figure 2: Location of selected stations in the study area(Mon State and Tanintharyi Region)

3.2 Inverse Distance Weighted (IDW) Interpolation

Spatial wind mapping need to be established to well-known in the wind characteristic of the proposed site of the structures. Spatial wind mapping using geographic information system (GIS) can provide a compact, informative picture of wind data. To obtain the wind mapping using ArcGIS 10.3.1, this study selects seven stations in southern region of Myanmar. Moreover, the additional twenty stations in the contact surrounding areas of the study area are taken into account to be convenience in using IDW interpolation for the selected stations. Coordinate system or map projection is necessary for GIS mapping. In this study, coordinate system for the spatial wind speed distribution is based on the World Geodetic System (WGS84). Figure 3 is the wind map of the selected stations for mean wind speed (m/s) of 10 m height for year 2008-2017. The areas that have low wind speed or high wind speed can be determined by the colours from blue to red. It can be seen that mean wind speeds of 1 m/s or greater can be given by Thaton, Kyaikkhame and Kaw Thaung stations.

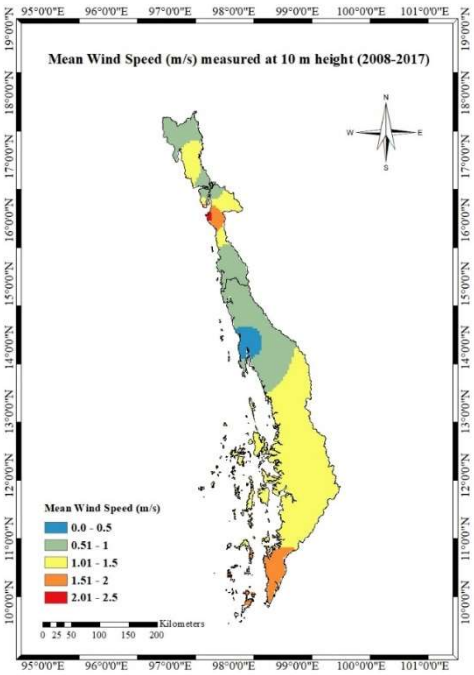

Figure 3: Interpolated mean wind speed of study area at measured 10 m height (2008-2017)

3.3 Wind Speed Extrapolation

Wind speed of the particular site can vary with height above the ground level. Wind profiles at various heights are essential in the design considerations of infrastructures and wind turbine constructions which are categorized into three major groups: household-size, rotor diameter less than 3 m, hub height below 50 m; medium size, rotor diameter from 10 to 15 m, hub height below 100 m; and large wind turbine, rotor diameter from 50 to 60 m, hub height are 100 m and above (Gipe, 2004). A survey showed that there was 47% of wind turbine with cut-in wind speed below 3 m/s, 38% between 3 to 4 m/s, and 15% above 4 m/s in the Europe wind turbine market (Wineur, 2005). Thus, this study is focus on wind speeds of 3 m/s or greater for the studied stations. Wind speeds for year 2008-2017 of the selected stations at the height of 30 m, 50 m and 100 m are extrapolated by power law based on measured wind speeds at the height of 10 m. Mean wind speed of the selected seven stations are illustrated in Figure 4 to Figure 10. It can be seen that most of mean wind speed at height of 100 m of Thaton and Kaw Thaung are 3 m/s or greater almost all years of the study period.

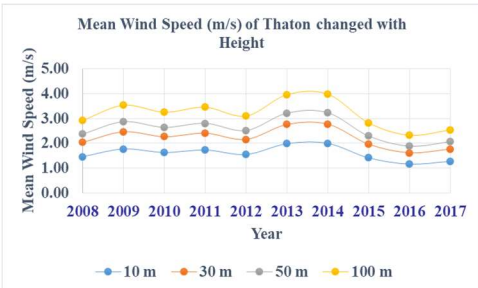

Figure 4: Mean wind speed (m/s) of Thaton (Mon State) changed with height (2008-2017)

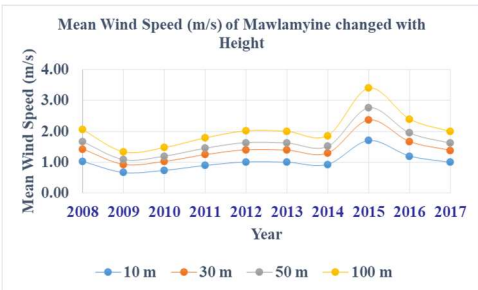

Figure 5: Mean wind speed (m/s) of Mawlamyine (Mon State) changed with height (2008-2017)

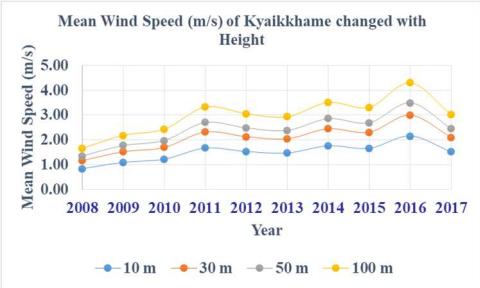

Figure 6: Mean wind speed (m/s) of Kyaikkhame (Mon State) changed with height (2008-2017)

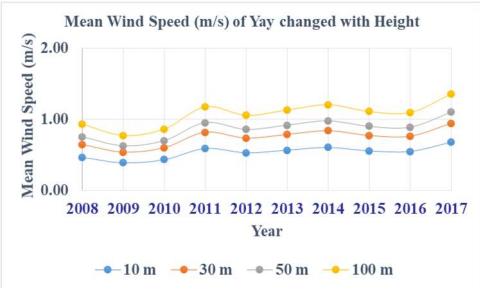

Figure 7: Mean wind speed (m/s) of Yay (Mon State) changed with height (2008-2017)

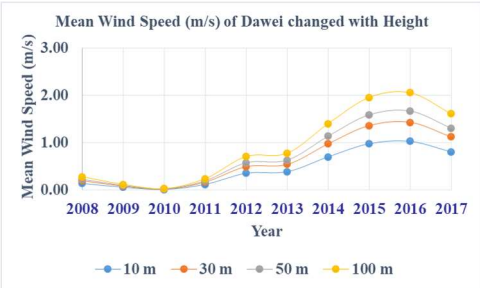

Figure 8: Mean wind speed (m/s) of Dawei (Tanintharyi Region) changed with height (2008-2017)

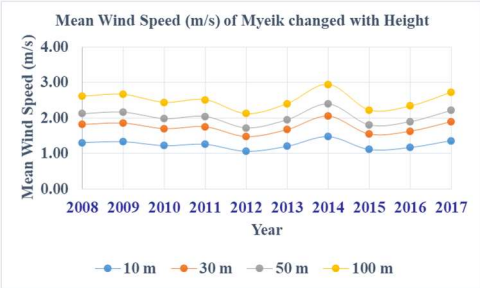

Figure 9: Mean wind speed (m/s) of Myeik (Tanintharyi Region) changed with height (2008-2017)

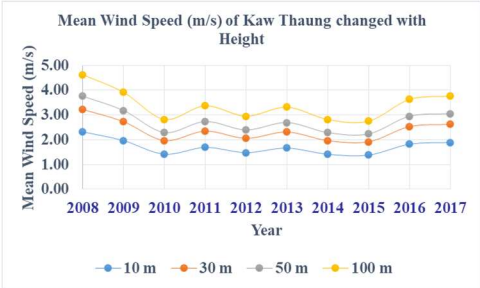

Figure 10: Mean wind speed (m/s) of Kaw Thaung (Tanintharyi Region) changed with height (2008-2017)

3.4 Weibull Distribution

Calculated shape and scale parameters of Weibull distribution for selected stations are summarized in Table 2. Functional curves of Weibull distribution for selected stations of Mon State and Tanitharyi Region are shown in Figure 11 and Figure 12. From Weibull distribution, shape factors for Myeik and Yay are 12.40 and 7.27 which describe these stations are less changes in wind speed with time. But wind speeds of these stations are only 1.29 m/s and 0.57 m/s, respectively.

Table 2: Weibull parameters

No	Station	Shape factor, k	Scale factor, c
1	Thaton	6.64	1.71
2	Mawlamyine	4.01	1.13
3	Kyaikkhame	4.52	1.64
4	Yay	7.27	0.57
5	Dawei	1.20	0.49
6	Myeik	12.40	1.29
7	Kaw Thaung	6.54	1.82

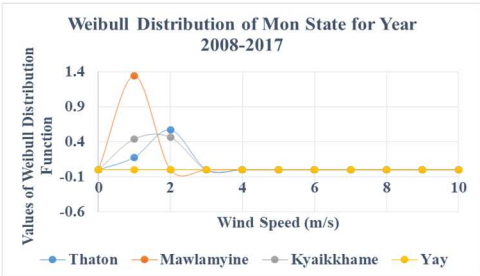

Figure 11: Function Curves of Weibull distribution (Mon State) for year 2008-2017 (Mon State)

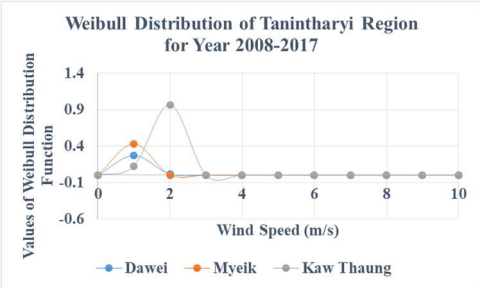

Figure 12: Function Curves of Weibull distribution (Tanintharyi Region) for year 2008-2017

Besides, shape factors for Thaton and Kaw Thaung are 6.64 and 6.54 with wind speed of 1.71 m/s and 1.82 m/s, respectively.

3.5 Rayleigh Distribution

Shape and calculated scale parameters of Rayleigh distribution for selected stations are summarized in Table 3. Functional curve of Rayleigh distribution for selected stations of Mon State and Tanitharyi Region are shown in Figure 13 and Figure 14. In Rayleigh distribution, among the selected stations, wind speed at Kaw Thaung and Thaton are 1.92 m/s and 1.8 m/s while the constant shape parameter is considered as 2.

Table 3: Rayleigh parameters

No	Station	Shape factor, k	Scale factor, c
1	Thaton	2	1.80
2	Mawlamyine	2	1.15
3	Kyaikkhame	2	1.68
4	Yay	2	0.60
5	Dawei	2	0.52
6	Myeik	2	1.42
7	Kaw Thaung	2	1.92

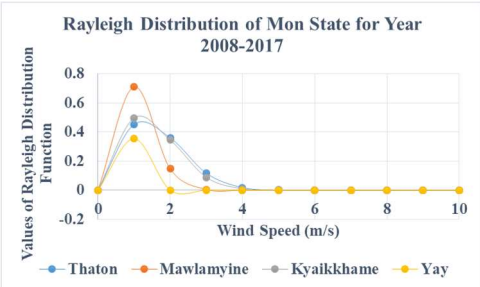

Figure 13: Function Curves of Rayleigh distribution (Mon State) for year 2008-2017

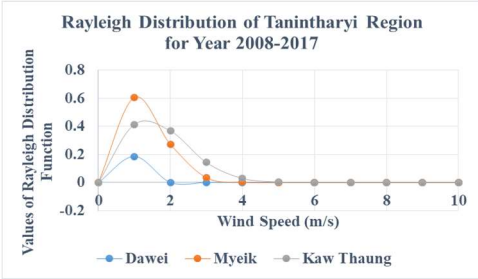

Figure 14: Function Curves of Rayleigh distribution (Tanintharyi Region) for year 2008-2017

3.6 Coefficient of Determination (R^2)

Coefficient of determination (R^2) of Weibull distribution and Rayleigh distribution are shown in Table 4. Coefficient of determination (R^2) of Weibull distribution and Rayleigh distribution are approach to unity. So, it proves that these two types of distribution are fitted for wind characteristics study of southern region of Myanmar.

Table 4: Coefficient of Determination

	Weibull Distribution	Rayleigh Distribution
R^2	0.998	1.000

4 CONCLUSIONS

Initial study of wind characteristics is essential to carry out the infrastructure constructions and wind system constructions. The results of this study intend to use in the suitable site selection for infrastructure constructions in the study area while attention should be paid for high wind characteristics in construction. In addition, the results can also be used in the wind potential site for wind energy production. From the spatial wind mapping, mean wind speed of Kyaikkhame, Mon State is the highest wind speed station during the study period. From the results of power law, it can be concluded that Thaton and Kaw Thaung are the stations that can give wind speeds of 3 m/s or greater. Weibull distribution parameters show that these stations can give higher mean wind speeds of 1.71 m/s and 1.82 m/s with stable wind condition of shape parameters 6.64 and 6.54. Rayleigh distribution parameter also show that these stations can give higher mean wind speeds of 1.80 m/s and 1.92 m/s with constant shape parameter set to two.

Moreover, R^2 of Weibull distribution is 0.998 while that of Rayleigh distribution is 1.000. These values prove that both types of distribution are suitable for analyzing of the initial wind characteristics of the proposed sites. Finally, it can be concluded that wind speed in Thaton, Mon State and Kaw Thaung, Tanintharyi Region are the most wind potential stations in the study area. Further study; logarithmic law of wind profile, wind direction with the aid of wind rose and other probability distribution function with more than ten years recorded wind data should also be considered.

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Application of Support Vector Regression for Solar Power Predication

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Abstract: In the past few decades, the rapid growth of the population and the increasing demand for quality living materials have led to the over exploitation of the petrochemical industry. It has caused serious damage and pollution to the environment, leading to possible climate change problems; thus, there is an immediate need to end man's dependence on non-renewable energy to reduce damage to the environment. The government of Taiwan is intensifying its efforts to use renewable energy sources particularly, solar energy, and has set a target of 20GW by 2025. The most important influencing factors of solar power generation are irradiance, environment temperature, and PV-temperature. With the influence of time and climate, the power generation is expected to fluctuate greatly, which may cause serious negative impact on power grid, power transmission, and distribution equipment. Therefore, a simplified electricity prediction method is proposed in this study. Based on the support vector regression, the input parameters used in this study for predicting daily power generation include irradiance, environment temperature, and PV-temperature. The experimental results showed that the accuracy rate of the daily power generation prediction was 99.11%, which is based on the support vector regression.

Keywords: Support Vector Regression, Support Vector Machine, Solar Power Prediction

1 INTRODUCTION

In recent years, global warming and the rising awareness of environmental protection have promoted the use and development of renewable energy sources (RES), such as solar energy, wind energy, hydropower, and geothermal energy. These are considered solutions to the growing energy crisis (Wan et al., 2015). Among all RES in tropical countries, solar energy is considered to be the most feasible option. The use of renewable energy sources aims to provide safe, clean, and sustainable energy (Saber et al., 2014), which can relieve the current energy and environmental dilemma. Renewable energy sources are considered to be inexhaustible, and the system will not produce any pollution emissions during its operation. For these reasons, solar power generation has become one of the key points of global development (Ismail et al., 2015).

In 2017, the number of solar power systems installed in the world exceeded that of any other power generation technology systems. A total of 99.1GW solar power systems have been installed, with an increase rate of 30% from 2016. Taiwan's development in RES is dominated by solar power generation and wind power generation. The RES power generation capacity is expected to reach 20GW by 2025. The short-term goal of the project of Solar Photovoltaic 2-year Promotion Plan is to complete 1.52GW of solar power installation in two years. In the long-term plan, 3GW of roof type solar power installation and 17GW of ground installation are expected to be completed. The annual power generation goal is 25GW, which is expected to bring the total investment amount of NT 1.2 trillion.

As with any new developments, the rapid promotion of solar power generation comes with related problems. In order to study the impact of environmental parameters on solar power system performance, a monitoring system must be built for data analysis. The solar power monitoring system will collect and analyze the number of parameters measured in the solar power plant to monitor and evaluate its power generation performance. In order to ensure the reliability and stable operation of the solar power generation system, the monitoring system must be able to track various power generation indicators and failure sources (Madeti et al., 2017). The power generation capacity of the solar power generation system mainly depends on irradiance; however, the power generation capacity is anticipated to fluctuate greatly due to the influence of time and climate change, which may cause serious negative impact on the power grid, power transmission, and distribution equipment (Zendehboudi, 2018), as well as increase the difficulty of power management. If the operators of solar power generation system consider long-term development, building a real-time monitoring system for solar power field for power generation management is a must; but it will inevitably increase the operation and maintenance costs. This study believes that developing a solar power generation prediction system will allow effective analysis of the important solar power generation parameters and maximum daily power generation, which could provide system operators with a basis for power management.

The purpose of solar power generation prediction is to ensure that the solar power field has the best power generation planning and hardware construction. The accurate power generation prediction can provide important information for operators and power system designers, and can help build the best solar power generation system and power management mode (Sobria et al., 2018). At present, there are many different methods of power generation prediction such as AR (Autoregressive), ANN (Artificial Neural Network), CNN (Convolutional Neural Network), and SVM (Support Vector Machine). All of them have their own advantages and disadvantages. This study adopted the support vector regression (SVR) to predict power generation capacity because this model is high fitting, simple, and intuitive. It uses linear combination of two or more variables to deal with classification and regression problems. It is widely used in business, social and behavioral sciences, biosciences, and other fields.

In this study, the power generation parameters were based on the performance monitoring criteria of the solar power system (IS/IEC61724:1998) (Touati et al., 2013). Considering the research limitations, irradiance, PV-temperature, and environment temperature were selected as environmental variables to predict the power generation capacity of the solar panels. The data used in the power generation prediction model was taken from the historical data of the solar power plant of Chiang Mai Rajabhat University in Thailand. Through the daily predicted power generation capacity generated by the prediction model, managers of

solar power fields can make the most accurate judgment when conducting power dispatching, which could extend the service life of the solar panels of power plants.

2 RELEVANT RESEARCH

The characteristics of solar photovoltaic energy are variable and unstable; thus, it needs to be supplemented by ventilation image data, such as solar radiation, environment temperature, relative humidity, wind speed, irradiance duration, and other meteorological data. Through the analysis of these meteorological data, the power generation capacity of the solar panel can be predicted and estimated. Solar power, as a renewable energy source, has obvious fluctuation in its generation, so meteorological data is particularly important in solar power generation systems (Mellit et al., 2008). Based on weather indicators, solar power generation capacity can be predicted. Some researchers pointed out that irradiance, environment temperature, PV-temperature, wind speed, wind direction, relative humidity, and air pressure are the most relevant indicators affecting solar power generation (Kolodenny et al., 2006). It is worth noting that irradiance and temperature are the most important, and other indicators depend on the demand configuration of the experimental field (Madeti et al., 2017).

The performance of a solar power generation system will change depending on PV-temperature. However, the PV-temperature has a positive correlation with climate variables (environment temperature, irradiance, and wind speed), which directly affect power output and system efficiency (Congedo et al., 2013). Scholars have conducted several tests by using artificial sun and wind to study the influence of PV-temperature on the parameters of wind speed, wind direction, and environment temperature. It was found that PV-temperature has a very high impact on wind speed, but was not sensitive to wind direction and environment temperature. The ubiquitous air pollution, consisting of dust and cement, which are often ignored, may seriously affect power generation efficiency. Cement is the main building material that often exists in the atmosphere of urban areas. When it is deposited on the surface of solar panels, it will cause reduced power output and short-circuit current (El-Shobokshy& Hussein, 1993).

A study showed that the solar module was affected by temperature, solar flux, and relative humidity in a tropical climate zone, therefore affecting power generation efficiency. The experimental results demonstrated that solar flux, output current, and the efficiency of solar modules have positive proportional relationship. It further confirmed that environment temperature has no direct impact on PV-temperature, but has an impact on solar electromagnetic flux. Therefore, under increased solar flux with low relative humidity, the output current and efficiency of the solar panel will be increased; meanwhile power efficiency will be decreased with increase in the working temperature. Moreover, relevant reports noted that the annual average temperature distribution in hot and humid climate area is about 28±1℃, while the relative humidity in the morning is about 80% or higher. Taiwan is located in a tropical and subtropical area, so it is necessary to include relative humidity as one of the factors that might affect solar panel power generation.

Based on the British Standard BSIEC61724 for cross comparison, scholars' importance ranking of weather indicators (Touati et al., 2017), and limitations of the experimental field, this study included irradiance, temperature, wind speed, relative humidity, PV temperature, and dust as the parameters for the experiment (see Table 1).

At present, a large number of methodologies for solar power prediction have been proposed; some of which used annual average irradiation and the efficiency of the used solar panels to predict the annual energy output. For example, Autoregressive (AR), Moving Average (MA), Autoregressive–Moving-Average Model (ARMA), and other methods are all based on weather conditions and the assumption that solar power is generated by irradiance at a constant temperature (Touati et al., 2017).

In 2010, scholars have proposed an automatic power prediction system which can monitor and predict short-term power generation capacity of a solar power system, so as to treat the prediction of future power generation capacity as a regression problem. The method was independent of any specific technology of solar power generation system to understand the relationship between the input parameters (environment parameters) and output parameters (production energies). This method can be used to detect the efficiency loss of a solar power generation system for future planning, and for

rapid and effective maintenance (Cococcioni et al., 2010).

In 2011, in order to accurately predict the power generation efficiency of grid connected solar power generation system and improve its safety and stability, scholars proposed a multivariate linear regression prediction model, which used the operation data of solar power generation system during sunny days, cloudy days, and from sunny days to cloudy days or from cloudy days to cloudy days. Using the prediction model of grid connected solar power generation system, various weather problems were solved.

Table 1: Solar Panel Power Generation Factors (most important to least important

Rank	Parameters
1	Irradiance
2	PV Temperature
3	Wind Speed
4	Temperature
5	Relative Humidity
6	Dust

The prediction results showed that the method was not only simple and accurate, but also suitable for solving random problems which could improve the operation stability of solar power generation systems (Guangming et al., 2011).

The linear model is relatively simple, but is mainly limited to the model linear trend. On the other hand, the nonlinear model is more flexible, but more complex. Among the nonlinear models, ANN (Artificial neural networks) model is one of the most widely used.

In 2004, scholars proposed a neural network to predict the power generation capacity of a solar power system. Scholars included power generation, irradiance, and PV-temperature generated by the solar photovoltaic system into the prediction model to obtain high accuracy (Ashraf & Chandra, 2004). In 2011, scholars applied ANN to the output prediction of solar power generation system, and used ANN and weather classification to establish real-time solar power prediction model (Ding et al., 2011).

Moreover, in 2014, scholars combined spatial model with artificial neural network technology and propose a new local prediction method of global horizontal irradiation (GHI). The model mainly used meteorological forecast as the input factor to overcome the lack of measurement data base (Amrouche & Le, 2014). In addition, some researchers combined ANN model with other models as a novel hybrid model to further improve prediction accuracy.

SVM (Support Vector Machine) is a very accurate classification technology, which is widely used in wind power prediction (Wang et al., 2015). In 2011, Japanese scholars developed a new prediction method based on SVM and used weather variables (including cloud volume) as input factors to predict the power generation capacity of 1 MW solar power plant in Kitakyushu, Japan (Da Silva Fonseca Jr et al., 2012).

3 METHODOLOGY

Support Vector Machine (SVM) is a supervised learning model and is the related learning algorithm in classification and regression analysis. The statistical learning method proposed by Vapnik in 1995 is based on the principle of structural risk minimization in computational learning theory. It shows the linear method in high dimension space, which is related to the nonlinearity of input space. The traditional learning methods usually use minimization of training error (empirical risk), while SVM uses minimization of statistical risk to find the maximized decision boundary, called hyperplane, that can separate two kinds of data (Hung et al., 2004). In SVM, it is assumed that there is a training data set $\{(x_i, y_i)\}$; among $1 \le i \le n$, $y_i \in \{-1, 1\}$, $x_i \in R^d$, x_i is the input variable, and y_i is the corresponding output result. It can be expressed as $y_i(w^T x_i + b) \ge 1, i = 1, ..., n.$ Through the training process of SVM, the maximum boundary 2/|w| of two different kinds of data can be obtained. The optimization process is shown in Equation 1.

$$\max_w \{2 / \|w\|\} \to \min_w \frac{1}{2} w^T w$$

$$\text{Subject to } y_i(w^T x_i + b) \ge 1, \ \forall i = 1, ..., n \quad (1)$$

The SVM, first proposed by Vapnik, has two main categories: Support Vector Classification (SVC) and Support Vector Regression (SVR). In 1997, Vapnik, Golowich, and Smola proposed an algorithm for SVM regression called Support Vector Regression (SVR) (Basak et al., 2007). The model generated

by SVM classification only depends on a subset of training data because the cost function used to build the model is independent of the training data beyond the boundary and ignores any training data in the error value, which is close to the model prediction. After SVR projects the data to the high dimension space through kernel function, it constructs the linear decision function in the high dimension space to realize the linear regression and to obtain a set of hyperplane to be used to separate different kinds of data sets.

Using SVR for regression analysis is the same as SVM wherein a hyperplane has to be obtained. The difference is that SVM needs to find a hyperplane with the largest gap, while SVR needs to solve the optimization problem as shown in Equation 2.

$$\min_{b,w} \frac{1}{2}\|w\|^2 + C\sum_{n=1}^{N} \max(0, |w^T Z_n + b - y_n| - \varepsilon) \quad (2)$$

Equation 2 contains a L2-Regularization problem, which is used to solve the optimization problem through Quadratic Programming. However, the phenomenon of overfitting should be given attention.

4 EXPERIMENTAL RESULTS

The solar power generation data set was from the adiCET solar field of Chiang Mai Rajabhat University in Thailand. The experimental field was a grid connected solar power generation system, which can generate 702KWh per year. The data period of this experiment was from February 1, 2017 to March 20, 2017, and from July 6, 2018 to July 26, 2018. Data was recorded from 0:00 to 24:00, for every 1 second; thus, there were approximately 17, 280 data in each sensor every day. About 2, 453, 712 data in total was made for cross-validation. Out of this, 70% of the data was used for model training, and 30% was used for model testing. Due to network and equipment failure, some data was lost; these missing values were ignored in this experiment. In order to accurately predict the solar panel power generation under specific environmental factors, SVR was adopted in this experiment as the core model. The environmental factors, including irradiance, outdoor temperature, and module temperature, observed in the experimental field were used as input factors for the prediction model.

After completing the SVR model training, data obtained for 10 days, beginning March 10, 2018 to March 20, 2018, was used for test prediction in this experiment. The experimental results showed that the prediction accuracy rate was as very high (99.11%) and the average value of MAPE (mean absolute percentage error) was 1.61%, as shown in Figures 1 and 2, and Table 2. In Figure 2, it can be clearly seen that the actual power generation capacity is almost consistent with the predicted power generation capacity. The average value of MAPE in Table 1 is 1.61%, which is of high accuracy.

```
[0.07262941 0.07266558 0.07271348 ... 0.77862582 0.73729067 0.69738262]
Accuracy: 0.9911305120635087
```

Figure 1: Accuracy Rate of the Experiment (99.11%)

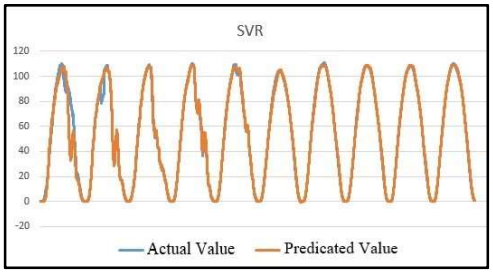

Figure 2. Comparison of *Actual* and Predicted Power Generation Capacity

Table 2: MPAE (%) Test of Mean Error

Date	3/10	3/11	3/12	3/13	3/14
MAPE(%)	8.69	1.96	0.06	0.21	0.62
Date	3/16	3/17	3/18	3/19	3/20
MAPE(%)	0.64	0.61	0.02	0.32	2.92
Average MAPE(%)		1.61			

5 CONCLUSIONS

Governments in various countries are paying more and more attention to the field of power management. After several years of development, new renewable energy sources technologies have been continuously proposed. For solar power prediction, due to the influence of weather variables, this study used SVR as the core for developing a power generation prediction model. The regression model was considered since it has many excellent characteristics, and the solar power generation capacity was assumed linear for the selection of historical data of relevant factors. These were imported into the

model for training in order to predict future power generation capacity.

The experimental results showed that the SVR model, composed of three related factors (irradiance, environment temperature, and PV-temperature), was able to accurately predict the power generation capacity. After cross-validation, the accuracy rate of the results was 99.1%, and the average value of MAPE (%) during this period was 1.61%. From MAPE (%) validation, the error rate between the actual value and the predicted value was less than 10%, which is considered a high accuracy prediction. This study hopes to predict future power generation capacity at a lower cost. Although this experiment is considered a success, some problems have been found. During data collection, the sensors collected data in an "all-weather" setting, but the solar power system is not able to generate power at night; therefore, future research should include a condition judgment to improve the accuracy of prediction. In addition, it was found that data was easily lost during the process of uploading the sensor data of the solar photovoltaic system to the cloud database. This resulted in abnormal training model prediction; thus, a more stable sensor should be used to successfully transfer the data to the cloud database without the interference of weather factors.

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Semi-Transparent Photovoltaic Window Louvers for Building Integration Application

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Abstract: This work demonstrates the feasibility of using a semi-transparent photovoltaic window louver that has been integrated into a building. The ability of the PV window louver to generate electricity was analyzed as well as the temperature and luminance profile inside the building. The louver was installed at three different angel, 0º (fully open), 18º (partially open) and 90º (fully close) with respect to the horizontal and the data were collected from 8.00-16.00. It was found from the testing that the PV window louver was generated the maximum amount of electrical energy of 0.29 kWh/m2/day when the angle of the louver was fixed at 18º. On the other hand, installation of the louver at 0º (fully open) provided both the lowest temperature and the highest luminance inside the building with the average value over the day of 30 ºC and 1,587 lux, respectively. The PV window louver exhibits the conversion efficiency between 5-7% and their performance is affected by shadow due to roof overhang. The PV window louver allows the generation of electrical energy while allowing some portion of sunlight to enter the room and at the same time provides the ventilation for the building. This offers the solution for the building integration where the PV window louver can be used to generate electricity and at the same time the temperature and luminance level inside the room can be controlled by it.

Keywords: Building integrated PV (BIPV), Semi-transparent, PV window louver.

1 INTRODUCTION

Currently, solar energy is extensively being used throughout the world due to its high reputation as a clean source of energy and environmental friendly. Solar energy can be directly converted to either electrical energy using a solar panel or to thermal energy using a solar collector. Changing the power from the sun right to electricity has been received a great deal of attention since the output can be used straightforward as a DC power source. For the AC system, on the other hand, an inverter is required to change DC to AC signal where the output signal matches the requirement of AC appliances. The main material used to fabricate the solar panel is call a semiconductor, mainly Si (Silicon). The conversion efficiency of Si solar panels can be varied between 5-18% depending on the quality of Si semiconductor (i.e. monocrystalline, polycrystalline or amorphous) (Wasfi, 2011).

The installation of solar panels can be done in several configurations. Solar farms require the panels to be installed on the ground where a large empty land space is needed. On the contrary, less empty space in the city forces the owner to attach the panels with the building where the panels can either be installed on the building (Building Attached Photovoltaic : BAPV) or can be integrated with the building (Building Integrated Photovoltaic : BIPV) (group, 13.november.2018, Peng et al., 2011). BAPV is the installation of solar panels on parts of the building such as on the wall or on the roof. While BIPV, the solar panel is installed as part of the building such as window, louver, roof or façade.

Window louvers are installed into the building as part of the ventilation system where the air inside the building can be exchanged with fresh air outside. At the same time, they are used to control the amount of light entering into the building (Ng et al., 2013). The louver also provides another advantage in which it requires smaller installation area compared to the conventional window. Two different louvers can be seen in typical buildings. The first type is usually made of wood or aluminum and the angle cannot be adjusted. The second type, which is more popular compared to the first type, is made of a transparent or opaque glass. The angle of the louver can be adjusted according to the requirement in order to optimize the air ventilation and luminance inside the room. The utilization of adjustable louver initiates the idea of integrating solar cells into glass window to create the PV window louvers that can be used to generate electricity and at the same time the louver can be used to control the luminance and temperature level inside the building. Here, we investigate the home-made PV window louver that is installed at a different angle. The window to wall ratio (WWR) is maintained in between 20-30% (Miyazaki et al., 2005, Evola and Popov, 2006). The parameters used to indicate the electrical performance of the PV window louver such as I-V curve, conversion efficiency, power and total energy are examined from the current-voltage characteristic that is being monitored throughout the day. Temperature and luminance profile inside the building is also measured during the day so the optimum angle of the louver can be obtained. Moreover, we have gained more understanding on the utilization of PV technology with the building.

2 THEORY

2.1 Principle of solar cells

A solar cell is an electronic device made from a layer of semiconductor, mainly silicon (Si), sandwiching between two metal electrodes. Solar cells directly convert the energy from the sun to electrical energy. Its fundamental principle relies on the photovoltaic effect. When sunlight hits the semiconductor, the energy is transferred to the valence electrons in the atoms. If the transferred energy is greater than the biding energy, the valence electrons will be excited to the conduction level and the electron-hole pairs are created. Build in electric field inside the p-n junction is used to separate electron-hole pairs into free charge carriers (free holes and electrons). These carriers then move to the respective electrode and, with the connection to the external load, the current will be flowed (Bodart and De Herde, 2002). It is noted that a single cell normally generates a very low amount of current and voltage which typically too low for any application. Therefore, various number of cells has to be connected in order to increase output power level (Sacht and Lukiantchuki, 2017).

The electrical performance of a solar cell can be investigated using the current-voltage characteristic (I-V curve) upon the incident of

sunlight. Figure 1 shows typical I-V curve of a solar cell. From the curve, maximum current and voltage can be obtained as displayed in the figure (Harmati and Magyar, 2015). Several parameters used to indicate the performance of the solar cell can be obtained as a result from current-voltage measurement. With known maximum current (I_m) and voltage (V_m), the maximum power (P_m) and the conversion efficiency (η) can be found using equation 1 and 2.

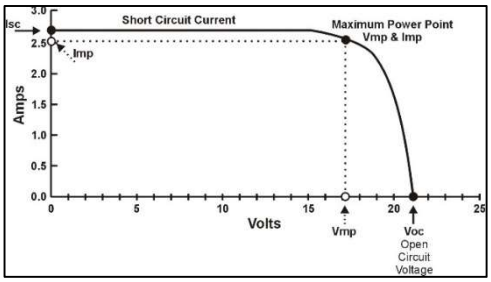


Figure 1: Current-voltage characteristic of a typical solar cell.

$$P_m = I_m \times V_m \quad (1)$$

$$\eta = \frac{P_m}{I_G A} \times 100\% \quad (2)$$

Where I_G is the intensity of the incident solar radiation (W/m^2) and A is the area of the solar cell (m^2).

2.2 Ventilation system

Air ventilation is related to the circulation and transfer of air inside the building to the outside. Two different air ventilation systems can be classified according to their principle which are mechanical and natural process (Markvart and Castañer, 2003). The mechanical ventilation system often uses the air duct distribution system or relies on the inlet-outlet air vent. Wall fan can sometime be seen to provide the air flow inside the building. The natural ventilation system, on the other hand, employs louvers or façades to transfer the air naturally from outside to inside and vice versa. Several parameters must be taken into account when using the natural ventilation system including the position of the sun, wind direction and storm path (Asfour, 2015) so that the building optimizes the air ventilation and minimizes high solar radiation during summer and rain during the rainy season. The size of the window must be carefully determined using the window to wall ratio (WWR) so that the optimum level of luminance and temperature inside the building is achieved. Acceptable WWR for typical building is ranging between 20-30% and it can be calculated using equation 3.

$$\text{WWR} = \frac{\text{Window area}}{\text{Wall area}} \times 100\% \quad (3)$$

2.3 Luminance in the building

The luminance level is very important for people who are using the building area and it must be properly designed to meet the requirement that is specified for each activity. Suitable luminance level ensures good visibility and low effect on eyesight. There are currently the international standards use for luminance level reference such as CIE (Commission Internationale de L'eclairage) and IES (Illumination Engineering Society) (Viessmann, 2015, Cho et al., 2012). The proper luminance level will be differed from one area to another depending on the requirement of light level for each specific activity as shown in table 1.

Table 1: The CIE and IES standard luminance level.

Area	CIE (LUX)	IES (LUX)
Meeting room	500	300
Office, library, computer room	500	300
Storage room	150	150
Rest toom	150	150
Corridor	100	150
Staircase	150	150
Elevator	150	150

Note: The number in the table is the average value.

3 METHODOLOGY

This section describes the experimental procedures which can be divided into three steps including construction of louver housing, production of photovoltaic window louver and testing procedures. The detail of each step is explained as the following.

The louver housing unit was constructed with the dimension of 2.28×3.24×2 m^3. The roof was tilted at an angle of 18° with the overhang of 30 cm. Metal sheet with a layer of insulator was used to create walls and roof. Two rectangular

open spaces, on the north and south side of the room, were created for the installation of louvers. In our case, the window to wall ratio was estimated to be 23.68%. Figure 2 demonstrates the completed louver housing unit. It is noted that the PV window louver was installed on the south side of the room to receive the maximum sunlight while pristine louver (i.e. louver without solar cell) was installed on the opposite side.

Figure 2: Louver housing unit.

In this work, polycrystalline silicon solar cells (ML solar) were used to fabricate the PV window louver. Each cell has the dimension of 7.62×15.24 cm^2 and is capable of generating the maximum power of 1.8 W (3.6 A, 0.5 V). Each louver plate contained two solar cells connecting in series (Figure 3) and the PV window was consisted of 20 louvers (40 cells) connecting in series (Figure 4). Table 2 summarizes the detail of PV window louver.

Figure 3: Position of solar cells on the louver.

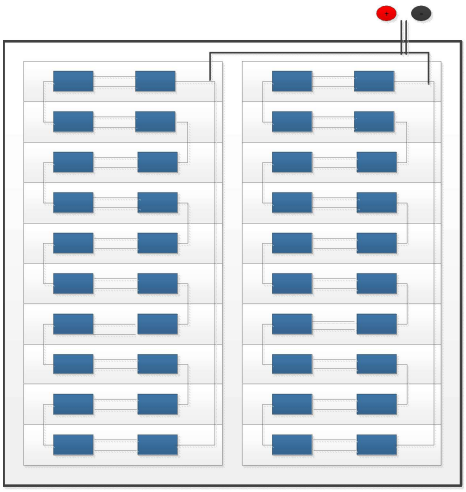


Figure 4: PV window louver.

Table 2: PV window louver characteristic.

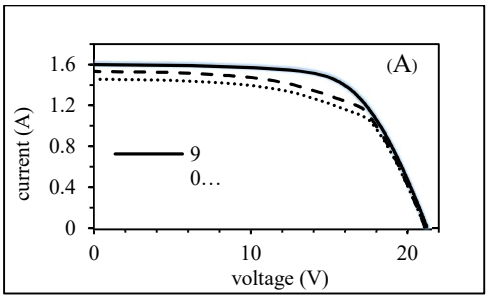
Characteristic	Detail
Number of solar cells	40
Space between each cell (cm)	11
Total solar cell area (m^2)	0.464
Transparent area (m^2)	0.615
WWR (%)	23.68

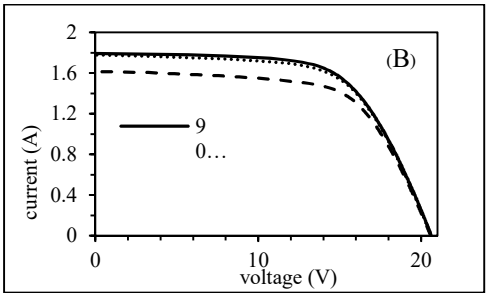
Electrical properties of the PV window louver were investigated using the PV module analyzer (PROVA 210) where the I-V curve of the panel was repeatedly traced every 5 min from 8.00-16.00. The incident solar radiation was obtained using the silicon light detector (SP-421-SS SDI-12 Digital Silicon-cell Pyranometer, Apogee instruments). The detector was placed on the louver to ensure similar sunlight incident angle. The type K thermocouple was used to measure the temperature profile inside the room and both the silicon detector and the thermocouple were connected to the data logger (Adam-500/TCP, 21 channels) for data acquisition. Luminance profile inside and outside the room was monitored using typical light sensor (BH1750FVI). The sensor was linked to Arduino for data acquisition.

4 RESULT AND DISCUSSION

The PV window louvers were installed at the angle of 0° (fully open), 18° (partially open) and 90° (fully close) with respect to the horizontal. The performance of the panels was tested between October-December 2019 and the data obtained on the clear sky condition were used to analyze the effect of the louver angle upon the electrical properties of the PV window louver, the temperature and luminance inside the room.

In the beginning, the PV window louver was examined through the I-V curves. Since the louver was home-made so the test was performed to ensure that the PV window louver provides a good photovoltaic property. Figure 5A-C show the I-V curves of the PV window louver that was installed at three different angles (0°, 18° and 90°) and measured at three different times (morning, noon and late afternoon). It can be seen that the PV window louver exhibits a typical I-V curve throughout the day as normally seen from a typical solar panel under the illumination of sunlight. However, the photovoltaic property seems to be disappeared in the late afternoon. This can be assigned to the low level of incident solar radiation and shadow from the roof overhang.





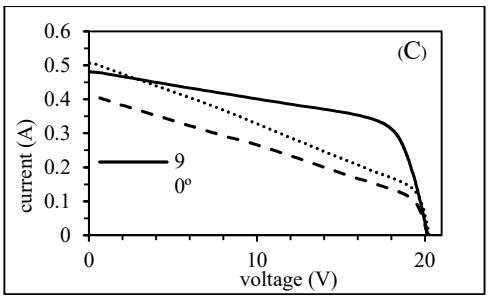


Figure 5: Current voltage characteristic of the PV window louver positioned at a different angle and measure at (A) 9.00, (B) 12.00 and (C) 15.00.

Table 3 displays the electrical properties of the PV window louver. Each number represents the average value over the day of testing (from 8.00-16.00). The efficiency of the panel was found to be in the range of 5-7.4% depending on the angle of the louver. The efficiency of the PV louver is relatively lower compared to typical solar panels available in the market. This might be related to the production process since our PV louvers were constructed using the low-tech procedures. The field factor (FF) was determined to be 0.57-0.65. The FF implied the quality of the solar panel and the value is lower than 1 because of the presence of the internal resistance of the panel.

Table 3: Electrical properties of the PV window louvers.

Angle (º)	I_{max} (A)	V_{max} (V)	FF	Efficiency (%)
0	0.94	15.13	0.57	5.06
18	1.08	16.38	0.645	5.55
90	1.04	15.77	0.62	7.4

Figure 6 shows the incident solar radiation profile on the PV window louvers. It can be clearly seen that the angle of the louvers affects the incident solar radiation. The amount of incident solar radiation depends directly on the position of the sun in sky. The incident solar radiation increased in the morning as the sun moving high up in the sky until noon where the peak value was seen. The peak solar intensity for louver angle of 0°, 18° and 90° was measured to be 960 W/m^2, 1,060 W/m^2 and 630 W/m^2, respectively. The incident solar radiation then reduced and, at about 14.00, the abrupt reduction was observed. This was because part of the louvers were covered by the shadow from the roof overhang. In the experiment, light detector was placed in the middle of the louver and it was not

affected by the overhang shadow in the morning. In the afternoon, however, the shadow from roof overhang grows and eventually the light detector was covered by it. During the time of testing, positioning the louvers at the angle of 18° provided the highest incident solar radiation throughout the day.

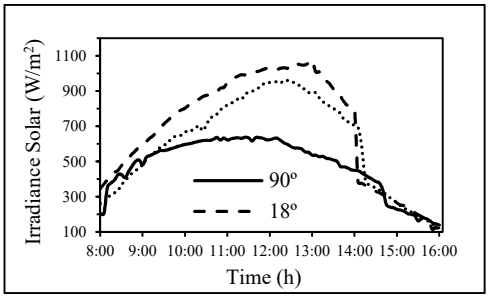


Figure 6: Incident solar radiation on the PV window louver positioned at a different angle.

Figure 7 shows the amount of output power for each PV window louver position. It can be seen that the electrical characteristic of the PV window louver changes with the position of the louver, time and area of roof overhang shadow. The generated power increased from 10-15 W in the early morning to about 22-25 W at noon. The power dropped rapidly after 12.30 and the panel generated almost no power after 16.00. The maximum power occurred from 10.00-12.00 when the louver angle is 18° and 90°. The result from Figure 7 seems to be contradicted to that from Figure 6 and this can be explained by the position of silicon light detector used to measure the incident solar intensity and the roof overhang shadow area. During the experiment, it was observed that the roof overhang shadow area on the louver positioning at 18° was largest and that positioning at 90° was lowest. Therefore, both panel can generate a similar amount of power throughout the morning even though the solar intensity on the louver at 18° was higher. As the sun was setting, the shadow area became larger for all condition and ultimately it covered almost all of the louver area (at about 14.00) and hence lower output power production from each louver was observed. The total electrical energy generated over a day from each louver can be found from the area under the curve of Figure 7. Here, the number represents the amount of energy per unit area of the solar cell. Positioning the angle of the louver at 18° offered the maximum amount of electrical energy of 0.29 kWh/m^2 while the angle of the louver at 0° provided the lowest one of 0.255 kWh/m^2.

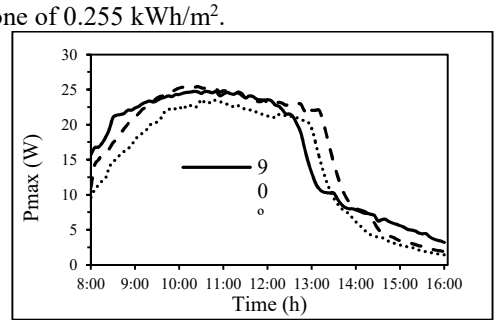
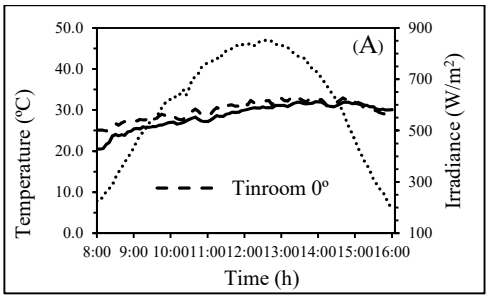
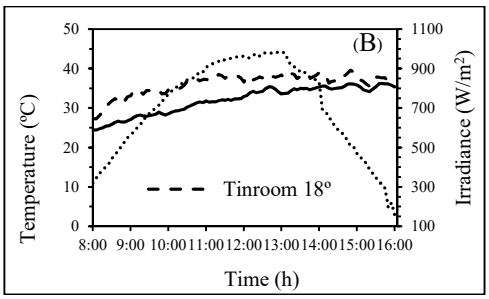


Figure 7: Output power from PV window louver positioned at 0°, 18° and 90°.

Figure 8A-C display the temperature profile both inside and outside the room when the angle of the louver was varied from 0° to 90°. It can be seen that the temperature inside the room was higher than the ambient in every louver angle. When the louvers were fully opened (Figure 8A), the temperature inside the room was relatively closed to the ambient temperature implying maximum air ventilation. The average temperature was found to be 30 °C and 29 °C for the inside and ambient temperature, respectively, with the average solar radiation of 600 W/m^2. The temperature difference between inside and ambient becomes greater when the louvers were fixed at a larger angle. The average temperature difference of 4 °C and 11 °C was observed for the louver angle of 18° and 90°, respectively.





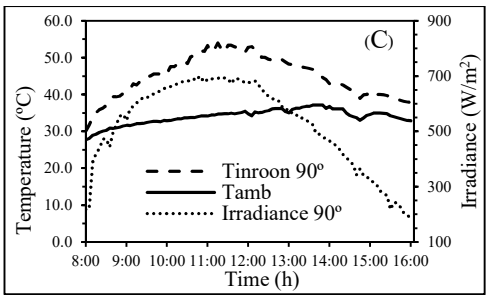


Figure 8: Temperature profile over the day inside and outside the room for the angle of the PV window louvers at (A) 0°, (B) 18° and (C) 90°.

It was clearly seen that the maximum temperature difference occurs during noon. Positioning the louver at 18° (Figure 8B) provides moderately air ventilation to the room and therefore the temperature inside the room remains just above that of the ambient. Completely close the louver (Figure 8C) prevents air ventilation to the room. The absorbed heat cannot escape from the room so the maximum temperature difference is seen.

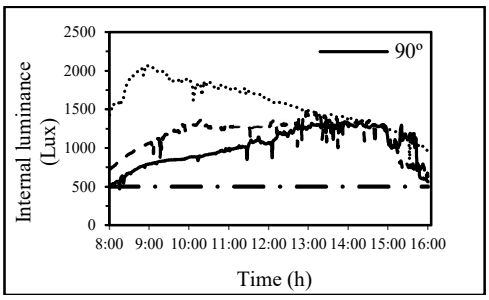


Figure 9: Luminance profile over the day inside the room for various PV window louver angles.

Figure 9 reveals the internal luminance profile for each PV window louver position compared to the standard luminance requirement for office room (500 Lux). The maximum internal luminance occurs when the louvers were fully opened (0°). Lower luminance level was recorded when the louver angle was increased. Each PV window louver position provides the internal luminance well above the standard requirement and no artificial light was required during the testing period.

5 CONCLUSIONS

The investigation of using home-made semi-transparent PV window louver with building was carried out for various positions of louver angles. Electrical properties as well as temperature and luminance profile inside the room were closely monitored over several days of testing. It was found that positioning the louver at the angle of 18° offered the maximum amount of electrical energy of 0.29 kWh/m^2. At this condition, the temperature difference between inside the room and ambient was only 4 °C and the luminance profile was found to be higher than that of the standard requirement for typical office room. This ensures that no artificial light is needed inside the room. Therefore, it can be concluded that fixing the louver angle at 18° offers the optimum condition for practical utilization.

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Comparison of Biodiesel Synthesis via Transesterification by Using Homogeneous and Heterogeneous Catalyst

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Abstract: The aim of this research was to compare biodiesel production from waste cooking oil by using homogeneous and heterogeneous catalysts. The homogeneous catalyst was potassium hydroxide (KOH) which was commonly used to make biodiesel through transesterification process. Heterogeneous catalysts on this work used calcium oxide from Commercial Calcium Oxide (CCO) and Natural Calcium Oxide (NCO) that derived from waste shells of mollusk named River Snail (Filopaludina martensi) through calcination process at 900 °C for 4 h. Transesterifications of Waste Cooking Oil (WCO) were carried out in laboratory scale with the concentration of catalysts (KOH, CCO and NCO) at 1-3%wt, 3:1-9:1 of methanol to oil molar ratio, reaction temperature at 60-65 °C, reaction time for 1 h and 300-500 rpm of magnetic stirrer. The results showed the optimal conditions of biodiesel productions by using KOH, CCO and NCO were 1%wt of catalyst concentration and MeOH/Oil molar ratio at 3:1. Biodiesel yields were 94.05, 94.79 and 94.75%, respectively. In addition, properties of obtained biodiesel were qualified according to Thailand's biodiesel quality standard that issued by the Department of Energy Business, Ministry of Energy, Thailand.

Keywords: Biodiesel, Transesterification, Waste cooking oil, Heterogeneous catalyst, Homogeneous catalyst

1 INTRODUCTION

Currently, the world's fuel demand is increasing whilst in fact, 85% of the world's energy is still supplied by fossil fuels (Hadiyanto et al., 2016). Therefore, searching renewable energy sources are heavily invested to replace the fuels. As an alternative solution, biodiesel has become an attractive option since it has low emissions (Lani et al., 2017), nontoxic and biodegradable (Che et al. 2018). The green-diesel can be produced from vegetable oils, animal fats and even from waste cooking oil (WCO), whereby triglycerides react with alcohol (mostly use methanol) in the presence of a catalyst (Lani et al., 2017) through transesterification method as in Figure 1.

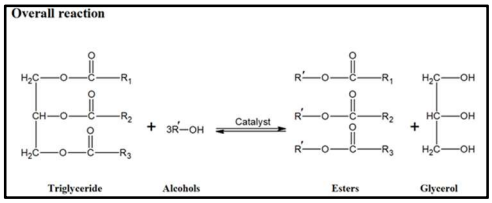

Figure 1: Transesterification reaction.

The production is catalyzed by using an either homogeneous or heterogeneous catalyst which sodium hydroxide (NaOH) and potassium hydroxide (KOH) have been extensively used in the industry because they usually produce biodiesel at high reaction rate owing to their high catalytic activity. Moreover, their prices are relatively cheap (Young and Sung, 2019). However, solubility in the reaction of the basic catalysts lead to the formation of soap or saponification that causes reduction of biodiesel yield (Uprety et al., 2016) as well as using these catalysts bring about to wastewater problem forasmuch it needs to be removed by water washing after the reaction complete. Hence, to avoid those disadvantages, one of the most frequent development is using of heterogeneous catalyst in the biodiesel production since it is easy and cheap for separation and regeneration (Widayat et al., 2017).

Overall, basic heterogeneous catalysts are preferred because they have higher catalytic activity than acidic ones (Moradi et al., 2015) and calcium oxide (CaO) is achieved the most attention among the others by virtue of its production that can be generated from calcium carbonate ($CaCO_3$) decomposition by calcination process of inexpensive or waste resources, such as eggshells, mollusk shells, animal bones or wood ashes. For mollusk shells, their main composition is 95-98% of $CaCO_3$ and the use of them as catalyst in biodiesel production has been investigated, the result showed that shell-based catalysts are very effective for biodiesel production (Hadiyanto et al., 2016).

In this present work, it was aimed to synthesize a low cost and highly efficient catalyst from natural or waste sources derived from river snail *(Filopaludina martensi)* shells which are found in several parts of Thailand. The synthesized catalyst was obtained through the calcination process and then it was used for the transesterification of waste cooking oil with methanol. Moreover, the produced biodiesels were compared with biodiesel production by using KOH and CCO as a catalyst. The effects of catalyst loading and methanol to oil molar ratio were studied. Likewise, properties of obtained biodiesels were also systematically determined.

2 MATERIALS AND METHODS

2.1 Materials

In this work, waste cooking oil, river snail (*Filopaludina martensi*) shells as Figure 2, calcium oxide (CaO) 90.0%, potassium hydroxide 85.0% and methyl alcohol (methanol) 99.9% were used as raw materials. WCO was obtained from Chedi Mae Krua agricultural group (Chiang Mai, Thailand) that using Morakot olein palm oil for deep-frying potato chips (Their properties about acid value, density and heat of combustion were analyzed by using ASTM D664, ASTM D1298 and ASTM D4809 standard, respectively.). The shells were collected from Number One farm (Pathum Thani, Thailand) and other chemicals are analytical grade purchased from Union Science, Thailand.

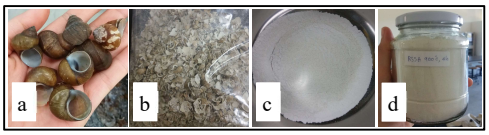

Figure 2: (a) River snail shells and (b-d) calcined river snail shell ash.

2.2 Catalyst preparation

On this work, biodiesel was produced from 3 different catalysts, the first was potassium hydroxide which is a homogeneous base catalyst that has been popularly used in biodiesel production through transesterification. Therefore, to compare biodiesel production by using heterogeneous catalysts, KOH was used in this study in the form of reference catalytic reaction. In an important way, because of this work aimed to synthesize naturally heterogeneous catalyst derived from the river snail shells which their main chemical composition is $CaCO_3$ that need to be changed into CaO by calcination process as Equation 1 before using it as a catalyst in the biodiesel production. Accordingly, the second catalyst was commercial calcium oxide (CCO) for comparison the obtained biodiesels using the catalyst in CaO form between commercial and natural resources.

$$CaCO_3 \xrightarrow{\text{Heat}} CaO + CO_2 \qquad (1)$$

The third was natural calcium oxide (NCO) that prepared from river snail shells by the following method. The shells were removed impurities by rinsing with deionized water several times in the first step and then were dried by using the heat of sunlight for 12 h. After that, the dried objects were pounded into smaller pieces. To decompose calcium carbonate ($CaCO_3$) of the shells into CaO form, they were calcined at 900 °C for 4 h in a muffle furnace (From the study of Kaewdang and Nirunsin, the chemical composition of calcined river snail shell at 900 °C for 4 h were showed percentage of CaO, MgO and Al_2O_3 and SiO_2 at 78.881%, 0.329% and 0.162%, respectively.) (Kaewdang and Nirunsin, 2017)). After that, the calcined river snail shell was crushed and ground into fine powder by using a mortar and pestle, then sieve them through a stainless- steel wire mesh. Lastly, the ash catalyst was kept in a desiccator to prevent catalytic deterioration.

2.3 Biodiesel production

Biodiesel on this research was produced through the transesterification process. The first step before generating biodiesel, WCO was pretreated to eliminate contamination and moisture by filtration and heating, respectively. After that, it was measured Free Fatty Acid (FFA) percentage to make sure it could be used in this biodiesel production process (It should be having %FFA lesser than 2%). Transesterification of WCO was carried out in laboratory scale which using 200 g of WCO with catalyst (KOH, CCO and NCO) concentration at 1, 2 and 3%wt, 3:1, 6:1 and 9:1 of methanol to oil molar ratio (MeOH/oil molar ratio), reaction time for 1 h and reaction temperature at 60-65 °C with 300-500 rpm of magnetic stirrer. After reaction completed, biodiesel, glycerol and solid catalyst phase were separated by using a separating funnel. Then invented biodiesels were analyzed yield percentage by Equation 2. Likewise, properties of obtained biodiesels such as pH, acid value (ASTM D664), density (ASTM D1298) and heat of combustion (ASTM D4809) were also systematically determined.

$$\text{Biodiesel Yield (\%)} = \frac{\text{Weight of Biodiesel (g)}}{\text{Weight of WCO (g)}} \times 100\% \qquad (2)$$

3 RESULTS AND DISCUSSION

3.1 Properties of Waste Cooking Oil

Waste cooking oil from deep frying potato chips that used in this work showed %FFA lesser than 2% (0.569%) that meant it could be used in this transesterification without passing deacidification by esterification process. And the other properties of WCO in Table 1 showed 6 of pH, density at 920 kg/m^3, acid value at 1.148 mg KOH/g oil and 34.64 MJ/kg of high heating value.

Table 1: Properties of waste cooking oil.

Property / Value	FFA (%)	pH	Density (kg/m^3)	Acid value (mg KOH/g oil)	High heating value (MJ/kg)
	0.569	6	920	1.148	34.64

3.2 Effect of Potassium Hydroxide

Potassium hydroxide is a homogeneous base catalyst which is a famous one that is extensively used in biodiesel production industry as well as sodium hydroxide for a long time due to it gives high catalytic activity. In this research, it was used for referential comparison of the results of biodiesel production with the heterogeneous base catalysts.

Effect of using methanol to oil molar ratio and KOH dosage in biodiesel production

from this WCO showed the data as Figure 2 (A) and (B) that were a graph of the relationship between biodiesel yield and methanol to oil molar ratio, and a graph of relationship between biodiesel yield and KOH concentration, respectively. From that data, it exhibited the best conditions of this biodiesel production were using 1%wt of KOH concentration and MeOH/Oil molar ratio at 3:1 since they did the highest biodiesel yield at 94.05%. Moreover, the figure showed using more MeOH/Oil molar ratio (3:1, 6:1 and 9:1) and the amount of KOH from 1-3%wt affected the declining trend in biodiesel yield as the study of Wadood and Marwa (2015) and Sahar et al. (2018). Excessive methanol usage unnecessary rise in cost of the process because alcohol recovery becomes difficult (MeOH/Oil molar ratios that usually lead to maximum yield were in the range of 6:1 to 9:1 (Verma et al., 2016).) and using too much KOH will cause of yield reduction as it bring more saponification or soap formation.

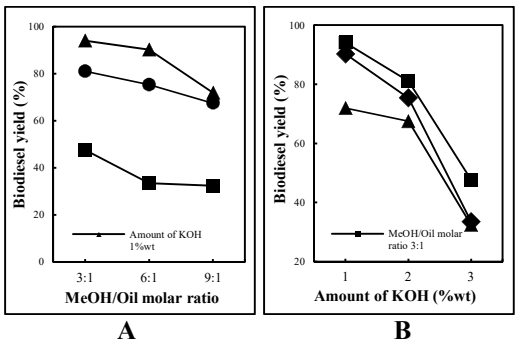

Figure 2: A relational graph of biodiesel yield based on A) Methanol to oil molar ratio and B) Amount of KOH catalyst.

3.3 Effect of Commercial Calcium Oxide

Calcium oxide is the most attentional catalyst on heterogeneous alkaline catalysis systems forasmuch it has higher catalytic activity than acidic ones. In addition, it can be generated from calcium carbonate resources by calcination process for decomposition of $CaCO_3$ to CaO form. Thus, to ensure studying of feasibility on this biodiesel production by using the naturally synthesized catalyst from river snail shell which is one of the $CaCO_3$ resources, CCO was used in this work for representation.

The results of biodiesel production from WCO via CCO catalyst by using reaction conditions, 3:1-9:1 of MeOH/Oil malar ratio and CaO loading at 1-3%wt presented in Figure 3 (A) and (B) that showed the best conditions were catalyst concentration at 2%wt and 3:1 of MeOH/Oil molar ratio because their brought about to 96.69% of biodiesel yield. However, using more methanol loading occurred from 3:1-9:1 ratio led to decreasing of the yield because by-product of glycerol form reacted with excessive methanol and hid reaction of methanol with the catalyst (Widayat et al., 2017). Addition catalyst concentration in the samples also was a result of biodiesel yield reduction with the same reason for unsuitable KOH usage.

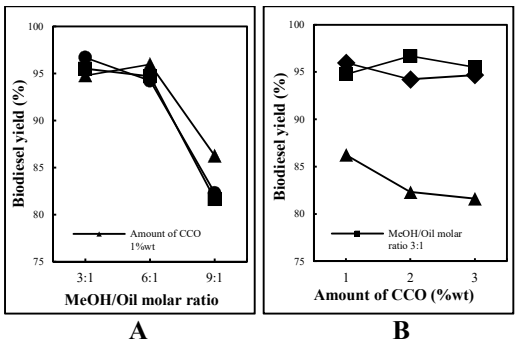

Figure 3: A relational graph of biodiesel yield based on A) Methanol to oil molar ratio and B) Amount of CCO catalyst.

3.4 Effect of Calcined River Snail Shell

Molar ratio of methanol to WCO (3:1, 6:1 and 9:1) and amount of the natural catalyst (NCO) from 1-3%wt in biodiesel production with biodiesel yield were exhibited in Figure 4 (A) and (B). From that data, they showed the best yield was 99.27% by using NCO concentration at 2%wt and 3:1 of the MeOH/Oil molar ratio. Moreover, these graphs showed biodiesel yield was in the same trend of Birla et al. (2012) studying (Biodiesel from waste frying oil using a heterogeneous catalyst derived from snail shell), Young and Sung (2019) research (Fabrication of a solid catalyst using coal fly ash and its utilization for producing biodiesel) and the biodiesel production via CCO in this work.

Transesterification using both of CCO and NCO had the best yield when using 3:1 of the MeOH/Oil molar ratio. In the same way, Singharun and Nirunsin (2017) found their synthesized CaO catalysts from natural waste resources gave the highest yield at 98.57% (Calcined coconut ash) and 95.32% (Calcined longan ash) of biodiesel generation from used

cooking oil. Widayat et.al (2017) reported their biodiesel production by using CaO derived from calcined limestone could obtain maximum at ratio of methanol to oil 9:1. Moreover, Kaewdang and Nirunsin (2017) found using calcined river snail shells (900 °C for 4 h) in biodiesel production from used cooking oil could give the highest yield at 94.86% by using 6:1 of MeOH/Oil molar ratio, 2%wt of the catalyst, 60-65 °C of reaction temperature and 3 h of reaction time. So, this research was better than previous research, because it could save more methanol as a reactant.

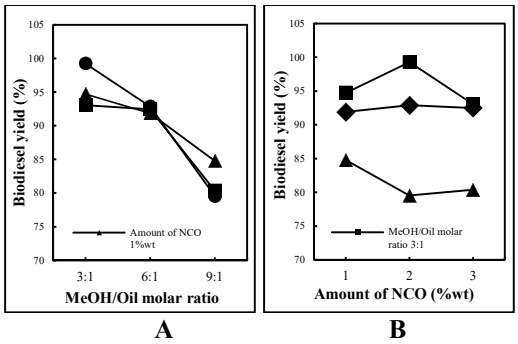

Figure 4: A relational graph of biodiesel yield based on A) Methanol to oil molar ratio and B) Amount of NCO catalyst.

3.5 Overall Image of Biodiesel Production

For discussion of feasibility to bring NCO as a catalyst in biodiesel production, the overall image of yield relationship between catalyst dosage and methanol to oil molar ratio were shown at Figure 5 and Figure 6 that consisted of biodiesel yield graphs on 3 different catalysts, KOH, CCO and NCO, respectively. They indicated taking the heterogeneous catalysts for this biodiesel generation from the waste cooking oil were possible and effective because they provided a rather high yield. In addition, all data of 3 catalysts had identical trends.

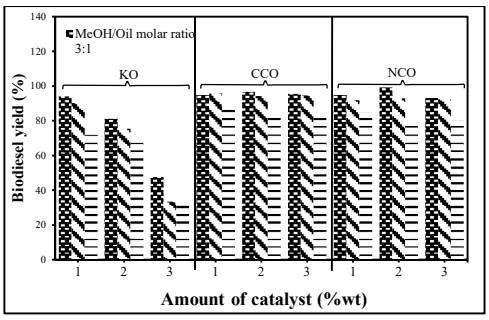

Figure 5: A graph of biodiesel yield relationship between each of catalyst dosages.

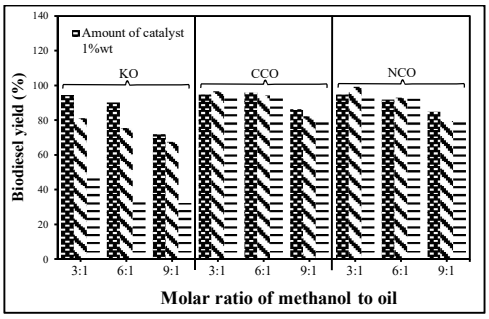

Figure 6: A graph of biodiesel yield depended on methanol to oil molar ratio condition in each type of catalysts.

3.6 Properties of biodiesel

The obtained biodiesel from the transesterification process that accelerated by using 2 types of catalysts (KOH for homogeneous, CCO and NCO for heterogeneous catalysis) were analyzed physical properties as Table 2 that included pH and others by following ASTM standards, ASTM D664 for acid value and ASTM D4809 for density.

Table 2: Properties of biodiesel.

Type of catalyst	Molar ratio of methanol to oil	Amount of catalyst (%wt)	pH value	Acid value (mg KOH/g oil)	Density (kg/m^3)
KOH	3:1	1	6	0.337	875
		2	6	0.222	870
		3	7	0.447	870
	6:1	1	7	0.328	870
		2	6	0.224	875
		3	7	0.776	870
	9:1	1	7	0.331	875
		2	7	0.332	875
		3	7	0.331	870
CCO	3:1	1	7	0.444	870
		2	7	0.404	880
		3	7	0.419	875
	6:1	1	7	0.272	880
		2	6	0.212	875
		3	6	0.165	875

Type of catalyst	Molar ratio of methanol to oil	Amount of catalyst (%wt)	pH value	Acid value (mg KOH/g oil)	Density (kg/m^3)
	9:1	1	6	0.428	900
		2	6	0.320	880
		3	6	0.471	900
NCO	3:1	1	6	0.366	900
		2	6	0.447	900
		3	6	0.422	900
	6:1	1	6	0.315	900
		2	6	0.317	900
		3	6	0.425	900
	9:1	1	6	0.385	890
		2	6	0.217	890
		3	6	0.356	890

Using KOH gave 6-7 of pH, acid value at 0.222-0.776 mg KOH/g of sample and 870-875 kg/m^3 of density. For addition heterogeneous catalyst to avoid using chemical homogeneous into the reaction, CCO let biodiesel which had their merits about pH at 6-7, acid value at 0.165-0.444 mg KOH/g oil and 870-900 kg/m^3 of density. Besides, NCO provided 6 of pH, acid value at 0.217-0.447 mg KOH/g of sample and 890-900 kg/m^3 of density. By their properties consideration, the density and acid values of almost biodiesel obtained from all operating parameters were found values in the range of 860–900 kg/m^3 (similar to the study of Yasar, F., 2019) and not over than 0.5 mg KOH/g of oil, which were within the accepted limits of the standards.

Although achieved biodiesel from using KOH could reach better values of the properties than using CCO and NCO as a catalyst, biodiesel in the separation step need to be washed by water to get rid of the basic catalyst that why it produces more wastewater from the purification. In contrast, the heterogeneous catalytic processes provided more simple purification and using this catalyst type from the natural source could be made effective low-cost biodiesel producing process. Therefore, using NCO as a catalyst was possible in biodiesel production with it gave accepted values of the properties.

For investigation of the optimal conditions of biodiesel production on this work. The productive parameters were selected for measurement more property about the heat of combustion. Therefore, 3:1 of methanol to oil molar ratio in the different dosages of 3 catalysts (KOH, CCO and NCO) from 1-3%wt with reaction time for 1 h, reaction temperature at 60-65 °C and 300-500 rpm of magnetic stirrer were chosen because biodiesel production by using KOH, CCO and NCO could reach the highest yields at 3:1 of MeOH/Oil molar ratio. Table 3 exhibited biodiesel from KOH still had the optimal conditions at 3:1 of MeOH/Oil molar ratio and 1%wt of catalyst concentration as they gave the highest yield which properties within the accepted limits of the standards.

Table 3: Properties of biodiesel based on using 3:1 MeOH/Oil molar ratio.

Type of catalyst	Amount of catalyst (%wt)	Biodiesel yield (%)	Acid value (mg KOH/g oil)	Density (kg/m^3)	High heating value (MJ/kg)
KOH	1	94.05	0.337	875	39.82
	2	81.09	0.222	870	39.96
	3	47.61	0.447	870	40.13
CCO	1	94.79	0.444	870	40.76
	2	96.69	0.404	880	37.50
	3	95.51	0.419	875	36.91
NCO	1	94.75	0.366	900	40.96
	2	99.27	0.447	900	41.09
	3	93.05	0.422	900	37.85

Even though 2%wt of catalyst concentration with 3:1 of MeOH/Oil molar ratio could lead the production to the highest yield of biodiesel when using CCO and NCO as the catalyst, but considering the properties of biodiesel found the optimal conditions of two heterogeneous catalysts were selected at 1%wt of catalyst concentration and 3:1 of MeOH/Oil molar ratio because of they achieved biodiesel which had better properties than using 2%wt of catalyst dosage.

4 CONCLUSIONS

Our present study revealed that heterogeneous catalyst (CCO and NCO) could make good biodiesel because their results showed similar characteristics of properties to homogeneous catalyst (KOH). The optimum parameters of biodiesel production by using 3 catalysts had the same conditions, 3:1 molar ratio of methanol to oil, 1wt% of catalyst concentration, 60-65 °C reaction temperature and 300-500 rpm with reaction time for 1 h. Biodiesel yields were 94.05, 94.79 and 94.75%, respectively. In addition, the properties of obtained biodiesels were qualified according to Thailand's biodiesel quality standard that issued by the Department of Energy Business, Ministry of Energy, Thailand.

Although achieved biodiesel from using KOH could reach better values of the properties than using CCO and NCO as the catalyst, biodiesel in the separation step need to be washed by water to get rid of the basic catalyst that why it produces more wastewater from purification. In

contrast, the heterogeneous catalytic processes provided more simple purification and using this catalyst type from the natural source could be made effective low-cost biodiesel producing process. Therefore, using NCO as the catalyst was possible in biodiesel production with it gave accepted values of the properties.

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The Thermal Performance of the Novel Solar Collector Integrated with Phase Change Material

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Abstract: The objective of this research is demonstrated the thermal performance of the two novel solar collectors integrated with phase change material (PCM) riser comparing with the conventional flat plate solar collector without PCM riser. The two novel solar collectors and a conventional solar collector had a similar area of 0.22 x 1.09 m^2 installed at 18° facing to the south. Each novel collectors had two single copper tubes, the outside tube was water tube with 28.7 mm of diameter and inner tube was a riser tube filled RT42 PCM with a melting point between 38-42 °C. In this study, the PCM risers investigated with diameter of 10 and 16 mm. The water in system was circulated by pump though a gap between outside tube and riser tube for heat receiving from solar radiation. The experiment was conducted in outdoor testing following ASHRAE standard 93-2003 that the water mass flow rate per collector is equal to 0.02 $kg/s \cdot m^2$ and the inlet water temperature is controlled by electric heater at 35, 40, 45, 50, 55, 60, and 65 °C, respectively. The solar radiation, ambient temperature, inlet water temperature, outlet water temperature, and hot water temperature in a storage tank were collected during the day at School of Renewable Energy, Chiangmai. From the experiment showed that inlet water temperature increased, the heat loss from collector would increase too. The thermal performance of the novel solar collector with PCM riser provided the higher values than the conventional flat plate solar collector. The novel solar collector that integrates with PCM in 10 mm diameter riser (PCM2) gave the highest $F_R(\tau\alpha)_e$ and F_RU_L of 0.815 and 11.140 $W/m^2 \cdot K$ following by 16 mm diameter riser (PCM1) let the values of 0.788 and 11.050 $W/m^2 \cdot K$ and the conventional solar collector gave the values of 0.713 and 10.642 $W/m^2 \cdot K$, respectively.

Keywords: The Novel solar collector, Thermal performance, Riser phase change materials, Solar water heater.

1 INTRODUCTION

Presently, human attempts to seek the alternative energy instead of the conventional fuel like fossil fuel. Many renewable energies such as wind, hydro, especially solar energy that are reliable and in abundant on earth can compensate. Heating system is an important system for buildings facility from fossil fuel production in households and industrial sector. By the ways, most building heating systems use in the range of low temperature for daily usage that is generated from fossil fuel but can be replaced to solar energy. Solar energy is free, clean, and can transform to electricity and thermal energy during daytime. The conventional of the solar collector system is built from a metal absorber plate. Its temperature is in a range of 40-70 °C (Kiatsiriroat, 2014, Gautam et al., 2017, Kalogirou, 2014). Many researchers try to find the newly technique will enhance the solar collector performance. The using nano-particle as a working fluid in solar collector is the alternative option gives the heat transfer enhancement higher than normal style (Kiatsiriroat, 2014, Syam Sundar et al., 2018, Sharafeldin et al., 2017, Mirzaei, 2017, Sharafeldin and Gróf, 2018, Muhammad et al., 2016). However, the modern technique with the nano-fluid is given a dropping heat transfer when using in a long time. There is a new option, the twist-tap or helical coil inserted into the absorber tube of the collector which is directly contacted to the water or working fluid during operation (Jaisankar et al., 2009, Saravanan et al., 2016, Eiamsa-ard and Seemawute, 2012, Murugan et al., 2019). Due to the fluctuation of solar radiation during daytime, the thermal energy storage has been designed and integrated on solar collector while the energy stored as phase change materials (PCM) is chemical composite materials which stores thermal energy by its latent heat during a melting point or freezing point. The capable of thermal is from more sensible thermal storing and the most command applications that benefit from PCM including those with known duty cycles (ICNQT, 2018, Bellan et al., 2015, Loem et al., 2019). The solar collector integrated with phase change materials (PCM) was studied by various researchers to investigate the abilities of the system during in sunny day and cloudy day operation. Khalifa et al. (Khalifa and Abdul Jabbar, 2010) studied the performance between a solar hot water system storage to the conventional which built from 6 copper tubes of 80 mm outside diameter and PCM was installed at a back of the copper plate. The result showed that the system could reduce heat loss by the PCM heat storage and an acceptable of mathematical analysis and experimental data were analyzed. Guta et al. (Gupta et al., 2017) studied the investigation of heat removal and the performance of solar collector with various flow configurations. The working fluid was flown in riser tube by using PCM filled in external tube. The result showed that the parallel wall to wall flowing was given the high performance than other flowing condition with observing in the case of phase change materials. Furthermore, the heat removal factor F_R was influenced to the melting of PCM more than the mass flow rate, during phase change the PCM absorbed thermal energy which was decreased the factor F_R, increased during the sensible heat stage. Koyuncu et al. (Koyuncu and Lüle, 2015) studied the performance of a domestic chromium solar water collector with PCM which arranged tube for water circulated and filled PCM. The results showed the collector efficiency was equal to 59% at the mass flow rate of 0.02 $kg/s \cdot m^2$. Papadimitratos et al. (Papadimitratos et al., 2016) studied the performance of solar water heater with evacuated tube filled the dual phase change materials. The efficiency could improve of 26% for the normal operation and 66% for stagnation mode.

In this research aims to investigate the novel solar collector integrated with phase change materials (PCM) filled inside copper tube. The PCM riser would be inserted through the absorber plate tube with using water as a working fluid for directly heat exchanger between the absorber plate and PCM. The experimental data was studied parameters for thermal efficient analysis following to the ASHRAE Standard test (Polvongsri, 2013).

2 EXPERIMENTAL SETUP

2.1 Solar collector configuration

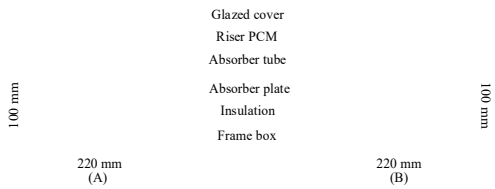
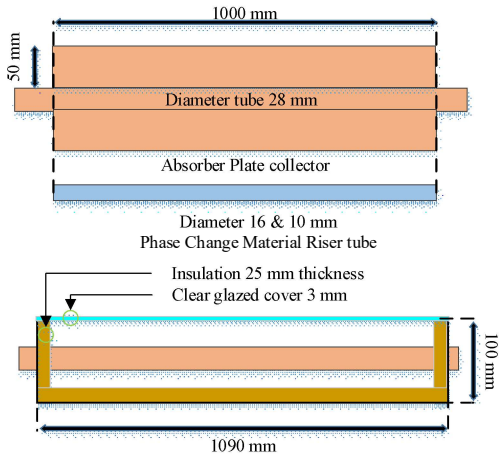
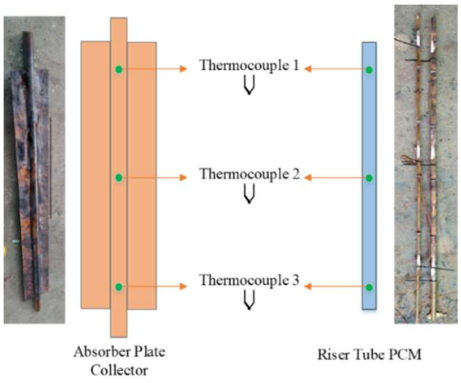


Figure 1: Schematic of (A) The solar collector without PCM and (B) The novel solar collector integrated PCM.



(A)



(B)

Figure 2: The novel solar collector (A) The absorber plate tube 28 mm of diameter and (B) The riser tube 10 mm and 16 mm of diameter.

The novel solar collector was built from a single copper tube as absorber plate tube of 28.7 mm outside diameter, 1 mm thickness and 1,000 mm length. The riser copper tube of 10 mm diameter and 16 mm diameter were inserted through the single copper tube and filled with RT42 phase change material (PCM) fully. The melting point of PCM between 38-42 °C (ICNQT, 2018). The absorber plate was painted as a normal black color for solar radiation absorption. A single clear glass of 3 mm thick was installed above the solar collector for make the inside temperature of collector higher than environment. The 25 mm of thickness rubber insulation was installed around the side and back of aluminum frame (Aroflex rubber with density of 40-70 kg/m^3) for heat loss reducing in the side and back. The final dimensions of novel solar collector are length 1090 mm the width 220 mm and height 100 mm as showed in the Figure 1 and Figure 2.

2.2 Experiment procedure

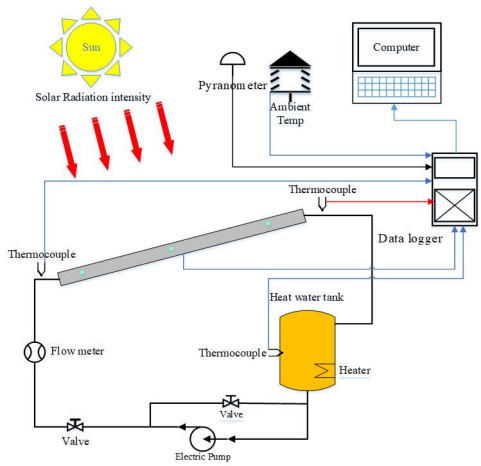
The novel solar water heater collectors integrated with phase change materials riser were given an abbreviation following the Table 1.

Table 1: The characteristic of solar collector integrated with PCM 1, PCM 2 and without PCM.

Category	Diameter	Unit	Inside
PCM 1	Ø 16	mm	RT 42
PCM 2	Ø 10	mm	RT 42
Without PCM	-	-	-

The experiment tested at the School of Renewable Energy, Maejo University, Chiang Mai, Thailand where located at 18.92 ° N latitude and 99° E longitude. In Figure 3 showed the novel and conventional solar collectors were installed at 18° tile angle facing to the south. Water was pumped from storage tank through the collectors by electric pump. The resistant heater in storage tank was used to regulate the water temperature during testing. The performance testing following to the ASHRAE Standard test 93-2003 (Polvongsri, 2013) which the most often used to evaluate of any solar collector design. The standard suggested the testing requires measurement under steady state condition which the solar radiation is more than 790 W/m^2, and the mass flow rate of water per collector area is equal to 0.02 kg/s·m^2. The rang of water temperature through solar collector was set up following 35, 40, 45, 50, 55, 60, 65 °C, respectively. The mass flow rate of water was measured by the manual

flow meter (Platon), gauge valve adjustment flow and has a bypass for overload preventing in the case of overpressure occurring. The solar radiation was collected by the pyranometer (Apogee SP-110-L-10). The thermocouple type K was used to measure the temperature that related many parameters and recorded in the data logger (TD-1947 SD and Adam 5000 PBC) every 5 minutes.



(A)

(B)

Figure 3: The experimental set-up (A) Diagram of testing (B) View of experimental collector.

2 THEORY

The performance of the solar collector is described by energy balance that indicates the incident solar energy and useful energy gain. In the steady state the useful energy output with the absorber plate area (A_C) and heat removal factor (F_R) which is mention by Bliss-William (Duffie and Beckman, 2013) as following eq. (1);

$$Q_u = A_c F_R \left[S - U_L \left(T_i - T_a \right) \right] \tag{1}$$

or the useful energy of the solar collector experiment of the energy output is calculated following eq. (2);

$$Q_u = \dot{m} C_P \left(T_o - T_i \right) \tag{2}$$

The thermal efficiency of solar collector is defined as the ratio between the heat gain from working fluid and the total incident solar radiation on the absorber plate area of solar collector (Duffie and Beckman, 2013, Polvongsri, 2013) as following eq.(3);

$$\eta = \frac{Q_u}{A_C I_T} = \frac{\dot{m} C_p \left(T_o - T_i \right)}{A_C I_T} \tag{3}$$

$$\eta = F_R \left(\tau\alpha \right)_e - F_R U_L \frac{\left(T_i - T_a \right)}{I_T} \tag{4}$$

The thermal efficiency test is presented at near normal incidence conditions therefore, that F_R is constant of maximum efficient, F_R and U_L are constant within the range of temperature. The linear will result when the efficiency is obtained from averaged data plated against $(T_i-T_a)/I_T$ according to Eq. (4). The intersection of the vertical line of efficiency axis is equal to $F_R(\tau\alpha)_e$. At this axis the temperature of working fluid that entered the collector near ambient temperature means that the collector efficient is nearly maximum. So, the slope of the linear line is equal to F_RU_L shows that the way energy has removed from the solar collector. At the intersection of the line with the horizontal axis collector efficiency is zero and this point normally calls the stagnation, usually occurs when no fluid flows in the collector.

3 RESULTE AND DISCUSSION

For solar collector performance analysis shows in the Figure 4 and Figure 5. Figure 4 presents the useful heat gain due to the inlet water temperature variation. Both of heat gain from the novel solar collectors integrated with PCM (PCM 1, PCM 2) showed that were higher than the collector without PCM at the mass flow rate of 0.02 kg/s·m^2. The PCM 2 with riser of 10 mm diameter was given higher heat gain than the PCM 1 with riser of 16 mm diameters which may effect of the energy storage in the phase change material that filled in the riser. Due to the heat gain of collector was influence with the temperature therefore the heat gains at the low inlet water temperature had slightly heat loss to environment while the high inlet temperature would give much losing thermal energy.

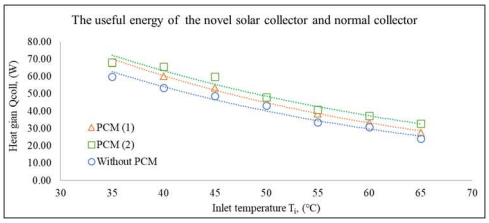


Figure 4: Useful energy gain of novel and conventional solar collectors.

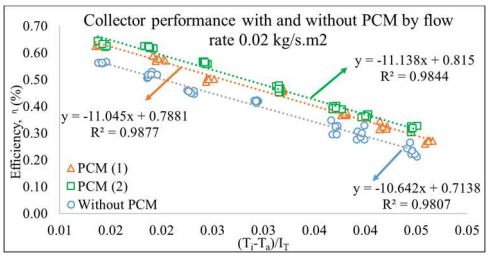


Figure 5: The thermal efficiency of novel and conventional solar collectors.

In the Figure 5 shows the thermal efficiency of the novel and conventional solar collectors were analyzed following the ASHRAE standard 93-2003. The linear equations of both collectors PCM 2 and PCM 1 could identify of the better system performance than the conventional solar collector without PCM. The range of inlet temperature, ambient temperature and solar radiation were given the relation of $(T_i-T_a)/I_T$ at X-axis, its value changed cause of the variation of inlet temperature during testing with steady state condition while the intersection on Y-axis presented the thermal efficiency $F_R(\tau\alpha)_e$. According to eq.(4), if the relation $(T_i-T_a)/I_T$ was slightly different, the collected thermal energy was closely to the maximum energy input as solar radiation. On the opposite, when the relation of $(T_i-T_a)/I_T$ had grown up, the energy loss would increase cause of the ambient temperature variation that showed as the slope of the linear equation or F_RU_L. The results showed that $(T_i-T_a)/I_T$ was varied from 0.01-0.05 °C·m^2/W. Both the novel solar collectors integrated with PCM were performed that PCM 1 and PCM 2 provided the $F_R(\tau\alpha)_e$ of 0.788, 0.815 and F_RU_L was 11.05, 11.14 W/m^2·°C, respectively while the solar collector without PCM got 0.713, and 10.64 W/m^2·°C as shown as in Table 2 with all case studies had the correlation on coefficient over than 0.98.

Table 2: The values of $F_R(\tau\alpha)_e$ and F_RU_L for the novel solar collectors comparing the conventional solar collector.

The standard test mass flow rate 0.02 kg/s·m^2

Category	$F_R(\tau\alpha)_e$	F_RU_L	R^2
PCM 1	0.788	11.05	0.987
PCM 2	0.815	11.14	0.984
Without PCM	0.713	10.64	0.981

In order to analyze the system analysis, the novel solar collectors and conventional collector were tested in daytime since 8:40 AM to 15:55 PM. The experimental results present by Figure 6 to Figure 9 that described the collector performance and showed the several of inlet temperature, outlet temperature and the storage tank temperature. In the Figure 6 shows the changing of the solar radiation intensity and ambient temperature during daytime. The maximum solar radiation was around 800 W/m^2 and the ambient temperature was about 31 °C.

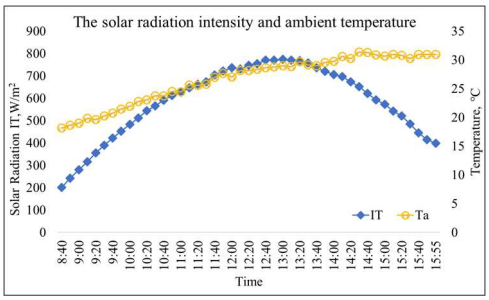


Figure 6: The variation of solar radiation and ambient temperature.

The experiment was investigated at the initial temperature in 10-liter storage tank of 25 °C and set the water mass flow rate of 0.02 kg/s·m^2. In the Figure 7 and Figure 8 were presented the variation of temperature change of the novel solar collector (PCM 1 and PCM 2). The maximum temperature different between inlet and outlet temperature was around 5.1 and 5. 5 °C, respectively during peak solar radiation and the ambient temperature average of 27.2 °C. For the maximum temperature of both water storage tanks were 50.2 and 51.5 °C, respectively while the conventional solar collector in Figure 9 shows the temperature different was around 4.8 °C and temperature close to the 50 °C.

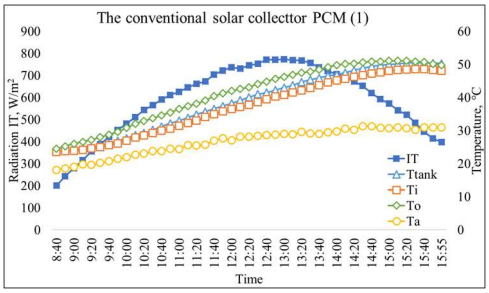


Figure 7: The temperature variation of the novel solar collector (PCM 1) during daytime.

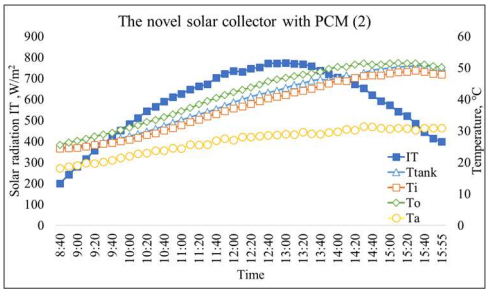


Figure 8: The temperature variation of novel solar collector (PCM 2) during daytime.

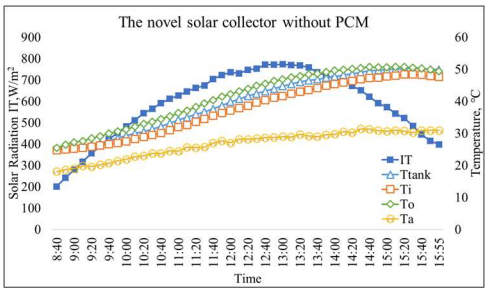


Figure 9: The temperature variation of conventional solar collector (without PCM) during daytime.

In Figure 10 shows the heat gain in the storage tank of each case studies. The heat gain (Q_s) would be varied by the solar radiation variation. At the solar radiation lower than 600 W/m^2, the heat gains both the novel collectors (PCM1 and PCM 2) and conventional collector (without PCM) were similar. When the solar radiation more than 600 W/m^2, the heat gain of both novel collectors were higher than the conventional solar collector. The calculated heat gains of using PCM 1, PCM 2 and without PCM were 1,126.3, 1,219.7 and 1,059.01 MJ, respectively. When considered in the term of thermal efficiency, both PCM collectors given the greater thermal efficiency about 8-10%.

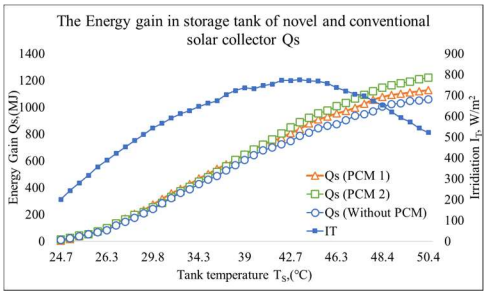


Figure 10: The heat gain in water storage tank of novel solar collectors and conventional solar collector.

4 CONCLUSIONS

The novel solar collector integrated with RT42 phase change material riser in difference diameter of 16 and 10 mm were tested under the ASHRAE standard testing with the mass flow rate per collector area of 0.02 kg/s·m^2 and the adjusted the inlet water temperature from 35, 40, 45, 50, 55, 60 and 60 °C. The results showed that solar collector that integrates with PCM in 10 mm diameter riser tube (PCM2) was demonstrated the

highest $F_R(\tau\alpha)_e$ and F_RU_L of 0.815 and 11.140 $W/m^2 \cdot K$. The collected data have been trust with the correlation coefficient over than 0.98. Moreover, both of novel solar collectors were given the higher thermal performance than conventional collector.

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APPENDIX

Nomenclature

$\dot{m}$	Mass flow rate of water	kg/s
C_p	Specific heat capacity	$J/kg.^oC$
I_T	Incident radiation intensity	W/m^2
A_c	Surface area of solar collector	m^2
F_R	Heat removal factor	-
T_o	Outlet water temperature	^oC
T_a	Ambient temperature	^oC
T_i	Inlet water temperature	^oC
T_{Tank}	Water tank temperature	^oC
Q_s	Energy gain of storage tank	MJ
$\dot{Q}_u$	Rate of useful heat gain	W
U_L	Overall loss coefficient of collector	$W/m^2\,^oC$
R^2	Correlation coefficient	
$(\tau\alpha)_e$	Absorptance-Transmittance produce	
η	Solar collector efficiency	

Table 3: value of parameters

Category	Value	Unit
I_T	801.21	W/m^2
$\dot{m}$	0.02	$kg/s.m^2$
T_i	35.6	°C
T_o	44.9	°C
C_p	4187	J/kg. °C
A_c	0.128	m^2

The useful energy calculation according to the Eq. (2): from the Table 3:

$$Q_u = 0.02 \times (0.127) \times 4187 \times (44.9 - 35.6)$$
$$= 65.028W$$

The thermal efficiency of the solar collector could be calculated according to the Eq.(3): from Table 3:

$$\eta = \frac{65.028}{801.21 \times 0.128}$$
$$= 0.62$$

Development of Biogas Fermentation Tank for Organic Food Waste in Chiangmai Community

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Abstract: Organic food waste in developing countries is a seriously environmental problem. Pa-Phai community (Chiang Mai, Thailand) is one of the affected areas. Therefore, the origin of this study was led household biogas system to the community for solving the issue. The purposes of this research were to develope biogas fermentation tank by addition a grinder on the top of tank for making it achieve high efficiency and studied about possibility of biogas production from two different organic food waste substrates, which were high COD level from Thai Local Noodle Shop Waste (TLNSW) and low COD level from Household Waste (HW). Both of two substrates were fermented with cow dung inoculum in Anaerobic Digester (AD). Biogas production by using TLNSW and HW were under the same ambient temperature, Hydraulic Retention Time (HRT) at 30 days with different Organic Loading Rate (OLR) at 2.26 and 1.20 kg COD/m^3 organic waste, respectively. The results showed total accumulative biogas volumes at STP of TLNSW and HW were 203.2 m^3 and 192.7 m^3, maximum methane fraction of biogas product were 62 and 60%CH_4, and COD removal efficiency were 86.2 and 76.7%, respectively. This research was expected to provide an important guideline for alleviating environmental problems due to organic waste and for developing a waste management system with the maximum efficiency. As the results, using TLNSW as substrate in biogas production was better than using HW. Moreover, both of low and high COD food waste were possible to generate biogas and this work was a good solution for food waste problem in the community.

Keywords: Organic food waste, Household biogas, Biogas fermentation tank, Anaerobic digestion

1 INTRODUCTION

Currently, orgnic waste from household is major problem, the waste management is still commonly use open dumping method which affects to environmental problem in several countries. Thailand is also encountering with this issue. The Pollution Control Department of Thailand reported organic waste collected by municipalities across the country in 2017 accounted for 64% of country's total garbage, or about 17.56 tons (Srisuwannaket et al., 2019). Therefore, it is important to solve this problem urgently. The residents of Pa-Phai community, Chiang Mai, Thailand (21,301 hectares of the area, 12,706 was approximately population in the present time) found solid waste is the main issue of their villages. So, they realized to the important of garbage disposal. Thus, this community was selected to the study area in this work for finding waste disposal solution.

For waste management, biogas system is the most attractive way to solve the problem because it has the potential to handle the waste and serves as a high-energy renewable fuel that can be used as a substitute for fossil fuels, the resulting can be burned as an energy source for cooking, lighting, or heating water (IRENA, 2017). Biogas from Anaerobic Digestion (AD) can be produced with several materials even food waste under ambient temperature and pressure condition (Seadi et al., 2008). Biogas from the system mainly composes of 50-70% of methane (CH_4), and 30-50% of carbon dioxide (CO_2) with traces of other impurities, such as hydrogen sulfide (H_2S), ammonia, and water vapor (Ge, X. et al. 2016). Normally, Co-digestion is always use for anaerobic digestion process to enhance biogas efficiency. For example, Hegde and Trabold (2019) studied the stability of anaerobic digestion with mixed cafeteria food waste as the main substrate combined in a semi-continuous mode with acid whey, waste bread, waste energy drinks, and soiled paper napkins as co-substrates, they observed a higher specific methane yield (SMY) of cafeteria food waste without any co-substrates was 363 mL $gVS^{-1}d^{-1}$ at organic loading rate (OLR) of 2.8 $gVSL^{-1}d^{-1}$. Process optimization by using co-substrates may help enable deployment of anaerobic digesters for food waste management in community and enable increased diversion of food waste from landfills (Hegde and Trabold, 2019).

Hence, for response and help the community for solving the problem, the researchers were relayed the knowledge about biogas production system under the project "The Encourage Biogas Production Project from Organic Waste in Household and Community Level" in Pa-Phai community, which the biogas system technology must be easy to use, easy to maintain, and suitable for household and community. Moreover, this work was supported the reduction amount of organic waste by using biogas production technology. The first purpose of this research was to develope and designed biogas fermentation tank by addition a grinder on the top of tank for making it efficiency and easy to use. In addition, this work was studied about possibility of biogas production from two different organic food waste substrate. However, the researchers hoped the outcome of this work can be one of environmental problem solutions that can help other communities.

2 MATERIALS AND METHODS

The experiments were divided into two parts. The first part was to develope and designed biogas fermentation tank by addition a grinder on the top of tank and the second part was studied about possibility of biogas production from two different organic food waste substrates, which were high COD level from Thai Local Noodle Shop Waste (TLNSW) and low COD level from Household Waste (HW). Both of two substrates were fermented with cow dung (CD) which used as inoculum in anaerobic fermentation tank.

2.1 Characteristics of Materials

The cow dung inoculum used in this experiment and organic food waste samples were obtained from Pa-Phai community. Both of two substrates were fermented with CD in anaerobic fermentation tank. CD, TLNSW and HW were tested for COD (Chemical Oxygen Demand) concentrations, total solid (TS), and pH values.

Their properties about COD, TS, and pH values were shown in Table 1. The parameters were measured before using in the biogas fermentation tank. The COD values of CD, TLNSW, and HW were 62,500.0, 90,500.0, and 52,100.0 mg/L, respectively. TLNSW had higher COD level that meant a greater amount of organic material contamination in the sample than HW, therefore

it was classified to high COD level. In contrast, HW was implicitly sorted to low COD level for comparison the result of using different COD level substrates in the biogas system.

Table 1: Characteristics of inoculum and substrates.

Properties	Materials			Unit
	TLNSW	HW	CD	
COD (Chemical Oxygen Demand)	90,500.0	52,100.0	62,500.0	mg/L
TS (Total Solid)	54.0	119.3	59.3	g/L
pH value	4.21-4.75	4.29-5.03	8.14	-

TLNSW, HW, and CD had total solid values at 54.0, 119.3, and 59.3 g/L, respectively. For more information about pH value, the measurements exhibited pH of 3 materials at 4.21-4.75, 4.29-5.03, and 8.14, respectively. Lower pH value materials have more acidity than higher pH value ones and that represent of more intensity of organic matter in several materials.

2.2 Biogas Fermentation Tank

The biogas fermentation tank as Figure 1 and 2 was carried out in a semi-continuous process with a total volume of 800 L, working volume of 600 L, and gas holder volume of 200 L. The biogas system was designed with a fermentation tank from HDPE (High Density Polyethylene) material that had very high density and corrosion resistant for supporting around 5-50 kg organic food waste per day (Nirunsin, S. 2011), mixing impeller with two blades was applied from Polyvinyl Chloride (PVC) pipe that had long about three quarters of the tank and it was controlled by manually operation. Moreover, the mixing in this research blended the substrates by axial flow technique because it is well suitable with such applications as liquid blending, or stirring needing a vortex (Kimball, M. 2016). The small grinder machine was installed at the top of the tank and it was rotated by hands (The shafts was generally rotated at 20-40 rpm of low speeds) for converting the waste from macro size into smaller size (About 0.5-2 cm) for easily decomposition.

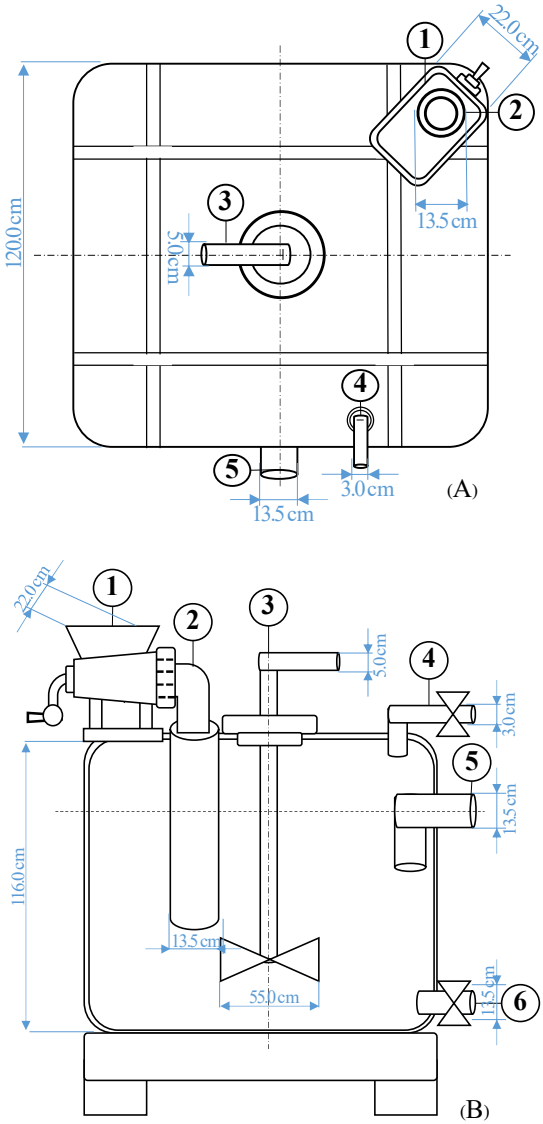

Figure 1: Biogas fermentation tank 0.8 m^3 as shown on top view (A) and side view (B)

(1) Grinder machine (4) Gas outlet
(2) Inlet pipe (5) Effluent sampling
(3) Mixer (6) Slurry outlet

From the schematic diagram, inlet pipe was designed to sink into the working volume to prevent gas leakage and the fermentation tank had one outlet at the middle for effluent removal. The pretreatment could enhance the biogas production and increase accessibility of the bacteria to the materials, which could give high efficiency of biogas production.

Operational process of this fermentation tank as shown in Figure 1 that could explain in

the following step. Firstly, CD was fed into the fermentation tank for preparation the inoculum of the system (just only one time to start the system), and then poured organic waste to the grinder (No.1) for converting the waste into smaller size about 0.5-2 cm that operated by using hands. After that, added the substrates into the inlet pipe (No.2) and then the mixer (No.3) was operated and mixed slurry to homogeneous substance then slurry was pushed into working volume of digestor tank for produce biogas. While operating the system, the slurry will be taken to measure COD, pH, and TS of influent and effluent by taking it out from effluent sampling pipe (No.5). In addition, generated biogas in gas holder volume part will be flown out through the gas outlet pipe (No.4) into the gas storage tank.

2.3 Experiment Procedure

Biogas fermentation tank was filled with cow dung and mixed well with water that contained of effective anaerobic bacteria. The occurring gas in the first phase of fermentation (After 2 weeks left) was released which were carbon dioxide (CO_2) and oxygen (O_2). The obtained biogas was measured by using portable gas check (Geotech, Biogas 5000).

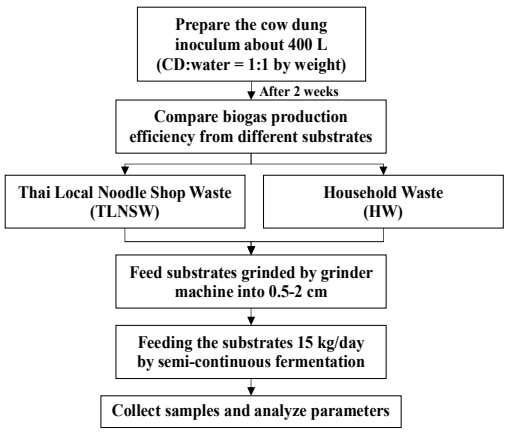

Figure 2: Experiment procedure.

Experiment procedure of this biogas fermentation as shown in Figure 2. All samples were carried out under the same ambient temperature (22.5-35.0 °C), The Hydraulic Retention Time (HRT) for 30 days with different Organic Loading Rate (OLR) at 2.26 organic waste of TLNSW and 1.20 kg COD/m^3 organic waste of HW. For feeding the materials, they were prepared by semi-continuous fermentation and the system would be started from taking 15 kg of organic waste material every day that was grinded finely with the small grinder. The well-mixed material was then poured into the biogas digester then the mixer would take to working volume (Once per day). The biogas fermentation tank consisted of fermented cow dung inoculum and organic food waste under anaerobic digestion process. When biogas was produced in the fermentation tank, biogas would stored in gas storage tank.

3 RESULTS AND DISCUSSION

3.1 Anaerobic Digestion Performance

The COD removal was exhibited at Figure 3 that showed COD removal of TLNSW and HW had the same of increasing tenor when the time was longer.

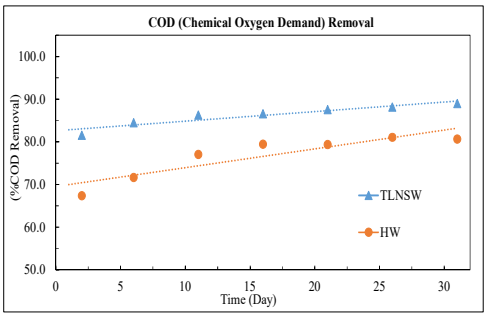

Figure 3: COD Removal of samples.

The COD values in this experiment were analyzed for 30 days that the samples were frequently analyzed every 5 days. The COD removals as shown in Figure 4 found TLNSW and HW were 86.2% and 76.7%, respectively. The data presented biogas system was successively fermentation due to bacteria in the process could continuously digest the materials (Nirunsin, R. 2016). COD values should be reduced for lifting efficiency of COD removal together with getting more efficiency of the system occurs when fermentation is provide with optimal retention time (Jia et al., 2011). More than that, the pH values of fermented slurry from table 2, which were 7.33-8.42 of TLNSW and 7.24-8.10 of HW that Young et al. (2015) found suitable pH range of digested slurry at 6.8-7.2 since it led biogas system to achieve higher yields (Young et al., 2015).

Table 2: Total solid and pH value.

Properties	Materials		Unit
	TLNSW	HW	
pH value	7.33-8.42	7.24-8.10	-
TS (Total solid)	7.60	20.30	g/L

The total solid of effluent samplings were 7.60 g/L of TLNSW and 20.30 g/L of HW that total solid removal at 85.8% and 82.9%, respectively. TS value showed about solid matter density in total mass of the substrates which lower total solid commonly incur good compatibility between raw materials and bacteria in biogas production (Winyangkul et al., 2010). Besides that, biogas production from these materials could give sufficient energy for using in household level by reason of the well rotated and grinded substrates in the tank and co-digestion could enhance the efficiency (Jia et al., 2011; Khandke, 2015).

3.2 Total Accumulative Biogas Volume

The biogas volumes of TLNSW and HW of this work gradually increased in the begining and then they stayed in the steady state due to the substrates were added continuously into the fermentation tank.

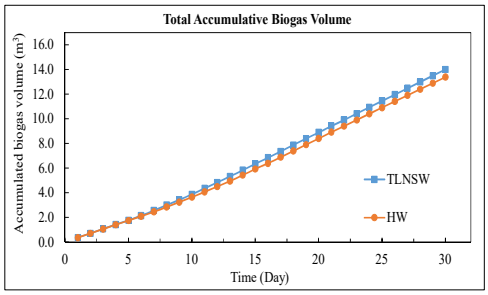

Figure 4: Total accumulation biogas volume.

According to the Figure 4 the total accumulative biogas volumes at STP of TLNSW and HW were 203.2 m^3 and 192.7 m^3, respectively. The results showed potential of this biogas digester tank that could be support both of high and low level COD substrate in the initial of reaction. Smaller particles of substrate had the advantage in anaerobic process. (Jitsoponpanya et al., 2013)

3.4 Biogas Composition and Biogas Production

A variety of factors affect the rate of anaerobic digestion and biogas production (Ayhan et al., 2016) such as pH value, circulation and COD content. The biogas composition was shown in Table 3, which were measured using portable biogas analyzer (Geotech, 5000).

Table 3: Biogas composition.

Biogas compositions			
Substrates	CH_4 (%)	CO_2 (%)	H_2S (ppm)
TLNSW	55-62	30-45	1-15
HW	55-60	35-45	1-13

The results showed biogas composition at STP of TLNSW and HW were methane fraction (%CH_4), carbondioxide (%CO_2), and hydrogen sulfide (ppm H_2S), TLNSW was indicated about average biogas consisted of methane at 55-62%CH_4, 30-45%CO_2, and H_2S 1-15 ppm. The sample of HW was contained 55-60%CH_4, 35-45%CO_2, and H_2S 1-13 ppm. Methane fraction of TLNSW and HW followed the biogas production standard. Mostly, biogas which produced from food waste have percentage of methane around 60%CH_4 (Poljun, 2014) same as the result of 20 m^3 biogas digester tank of military organization which was prototype and concept of this research. Methane fraction was contained around 55-60%CH_4 (Nirunsin, R. 2016).

4 CONCLUSION

This work was to develope biogas fermentation tank by addition a grinder machine on the top of tank and study about possibility of using organic food wastes which were high COD level (TLNSW) and low COD level (HW) form in the biogas fermentation tank with total volume at 800 L, working volume at 600 L, and gas holder at 200 L. The experiment was carried out in a semi-continuous process and co-digestion with different OLR under the same HRT and ambient temperature. The results showed, effects of using both of high and low COD levels had the similar results such as percentages of methane range about 55-62% and 55-60%, COD removal

at 86.2% and 76.7%, along with daily biogas volume at 466.7 L/day and 445.9 L/day, respectively. Biogas production from these materials could give sufficient energy for using in household level by reason of the well rotated and grinded substrates in the fermentation tank and co-digestion could enhance the efficiency of the biogas system. In summary, the developed fermantation tank of this research could be easily used, maintained, and suitable for using in household. Furthermore, the outcome of this work could be one of solid waste problem solutions in the community.

ACKNOWLEDGEMENTS

The authors would like to thank and acknowledge the School of Renewable Energy for master program study scholarship and support.

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The Combustion Characteristic of a Community-Scale Biomass Stove

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Abstract: The combustion characteristic of research article has concerning to evaluate the thermal efficiency, also the conductive heat transfer of the biomass stove for the community-scale in the rural area. An experimental use the Water Boiling Test (WBT) method to evaluate the thermal efficiency, also used corn cob as fuel. The research found that was 27.46% of the thermal efficiency. Fuel consumption ratio, FCR as 1.0 kg/h, the water boiling as 97 ^{o}C at 48 minute. The combustion zone has thermal conductivity of iron material as 3.06 kW/m^2 ^{o}C, the air zone has convective heat transfer coefficient of air as 0.24 kW/m^2 ^{o}C, and Thermal conductivity of air as 0.01 kW/m^2 ^{o}C, the concrete zone has thermal conductivity of concrete as 0.62 kW/m^2 ^{o}C.

Keywords: Thermal efficiency, fuel consumption ratio, conductive heat transfer, convective heat transfer, biomass stove

1 INTRODUCTION

Presently, the fundamental economic of Thai people have strongly relied on agriculture thus, the agricultural wastes such as wood chip, corn cob could be enormously generated. In the past, the conventional stove was widely used for cooking especially, in the rural area. Typically, the conventional stove has low efficiency. The inverse downdraft gasifier efficiencies were 10.59 – 14.13 % (Thongsan et al., 2015) and (Panwar & Rathore., 2008) found the thermal efficiencies of a 5kW was 26.5%. Normally, the biomass stove has been designed and develop for direct combustion widely used in households. In generally, the direct combustion biomass fuel as solid phase so difficulty burn in case of a high moisture contained. Then, design part has importance for developing and application for the community.

The propose research aims to evaluate the thermal efficiency, including the conductive heat transfer of the biomass stove by using corn cob as fuel.

2 EXPERIMENT SECTION

2.1 An experimental set up

This experiment has operated for 3 hours per batch, the fuel was corn cobs collected from the sunsweet factory, Chiang Mai, Thailand. Corn cob has heatting value 15,450 kJ/kg. The fuel input rate was 0.5 kg per 5 minutes, an air velocity was set to 3.10 m/s or air mass flow rate as 2.19 kg/s. The details of experimental tools and equipment are presented in Table 1.

Tabel 1 Instrument specifications

Lists	Specifics
Combustion chamber	Volume: 28 liters
Iron plate	Thickness: 2.0 mm
Insulator	Concrete
Centrifugal blower	Model :RV40-18/12H 12V/DC 430 mA, 5.2 W
Speed control	Volt input :12V/DC Volt output :0 –24 V/DC
Thermocouples	K-type/Temp: - 926 - 1,371 ºC
Data logger	Yokogawa Model : FX1012

Setting up an experimental by installing the instruments for operating biomass stove was showed on Figure 1 Schematic diagram of the biomass stove.

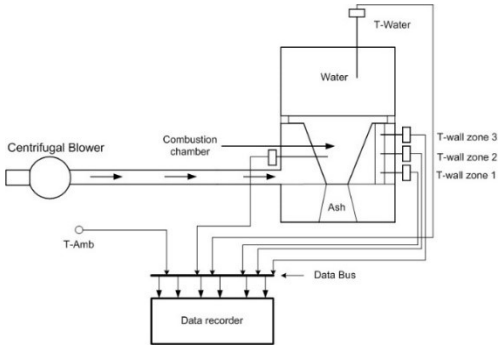

Figure 1. Schematic diagram of the biomass stove for experimental

The biomass stove can be divided into three components i.e. Combustion zone, Air-zone, and Insulator zone. The temperatures of various locations of the stove were measured. T-com is the combustion chamber zone temperature, T-com-surf is combustion chamber zone surface temperature, T-air-zone is air zone temperature, T-air-surf is air zone surface temperature, T-insu-zone is insulator zone temperature, and T-insu-surf is insulator zone surface temperature respectively. The data measurements used the data recorder to measure sampling rate every 4 minutes. Figure 2 shows the locations for observing temperatures. Stove setup and testing were showed in figure 3.

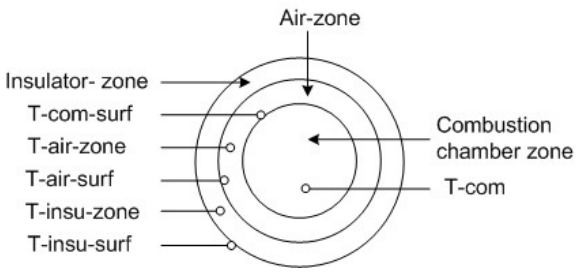

Figure 2. Location for installing thermocouples

Figure 3. Biomass stove set up and testing

2.2 Data analysis

The thermal efficiency testing methods can be peformed based on three methods such as Water Boiling Test (WBT), Controlled Cooking Test (CCT), and Kitchen Performance Test (KPT), as recommended by (Kanyaphorn at al., 2017). In this an experiment WBT-method was used for evaluating performance of the biomass stove.

The efficiency of biomass stove can be calculated using equation (1) (Sahataya at al., 2015).

$$\eta = \frac{m_i C_p (T_b - T_i) + m_e L}{m_f C_f} \quad (1)$$

Where η is combustion efficiency

m_i is volume specific of water

C_p is heat capacity of water (kJ/kg)

T_b is boiling temperature of water (°C)

T_i is begining temperature of water (°C)

m_e is water mass evapolating (kg),

L is latent heat of water (kJ/kg)

m_f is mass of fuel (kg)

C_f is heating value of fuel (kJ/kg)

Conductive heat transfer can be expressed with "Fourier's Law" and can be calculated with equation (2) (Cengel & Ghajar, 2015).

$$\dot{Q}_{cond} = -kA\frac{dT}{dx} \quad (2)$$

Where $\dot{Q}_{cond}$ is heat transfer (kW)

A is heat transfer area of the surface (m^2)

k is the thermal conductivity of the material (kW/m^2 °C)

dT/dx is temperature gradient – difference (°C)

The convective heat transfer can be explained by "Newton's Law of Cooling i. e. equation (3) (Saranyanit, 2002) and (Siwarasak, 2008).

$$\dot{Q}_{conv} = h_c A \Delta T \quad (3)$$

The convective heat transfer coefficient for air flow rate can be approximated using equation (4).

$$h_c = (10.45 - v) + 10^{1/2} \quad (4)$$

Where h_c is heat transfer coefficient (kCal/m^2 °C)

v is relative speed between object surface and air (m/s), (1.0 kCal/m^2 °C = 1.16 W/m^2 °C).

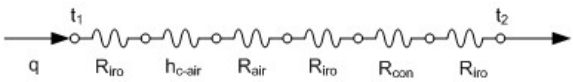

Figure 4. Heat transfer thermal resistance of biomass stove.

The conductive heat transfers thermal resistance of biomass stove. R_{iro} is Thermal conductivity of iron material at 0.58 W/m^2 °C. h_{c-air} is Convective heat transfer coefficient of air at 12.20 W/m^2 °C. R_{air} is Thermal conductivity of air at 0.0333 W/m^2 °C and temperature 125 °C. R_{con} is Thermal conductivity of concrete ranging (1.0 – 1.8 W/m^2 °C), (Saranyanit, 2002) and (Siwarasak, 2008).

3 RESULTS AND DISCUSSION

The thermal efficiency was 27.46%, the thermal efficiency found higher than an inverse downdraft gasifier of the Thongsan et al., (2015)

research articel and Panwar & Rathore., (2008). Because in this experiment used a air force convection and a big combustion chamber. The fuel consumption ratio, FCR about was 1.0 kg/h. The water temperature reached 97 degree celsius within 48 minutes, and the maximum combustion temperature was 833 degree celsius. The values are not standard testing on the atherhand the experimental results was expeained the performance of the biomass stove. The result isillutrated in Figure 5.

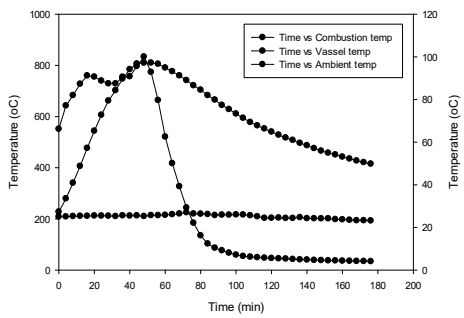

Figure 5. Characteristis of corn cob fule burn into the biomass stove testing.

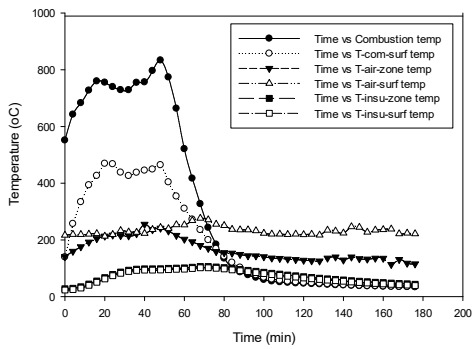

Figure 6. temperature profile of biomass stove testing.

Temperature profule is presented in Figure 6. It can be expained on the conductive heat transfer and the convective heat transfer of biomass stove tested. The combustion zone has thermal conductivity of iron material R_{iro} = 3.06 kW/m^2 ^{o}C.

The air zone has convective heat transfer coefficient of air h_{c-air} = 0.24 kW/m^2 ^{o}C, and Thermal conductivity of air R_{air} = 0.01 kW/m^2 ^{o}C, the concrete zone has thermal conductivity of concrete R_{con} = 0.62 kW/m^2 ^{o}C. The thermal conductivity of concrete was less than 1.0 that mean, the concreate is a good material for insulator because the value as low thermal conductivity.

4 CONCLUSIONS

The thermal efficiency of a community- scale biomass stove resrarch found that 27.46%, the combustion zone has loss from conductive heat transfer of the iron material about 3.06 kW/m^2 ^{o}C, the air zone has low loss than the combustion zone about 0.24 kW/ m^2 ^{o}C, including to the concrete zone has the conductive heat transfer was 0.62 kW/ m^2 ^{o}C. Then, concrete can be insulator of the biomass stove. The biomass stove for a community- scale by using corn cob as fuel more effictive to the rural communities for reducing LPG- fuel consumption and saving cost of fuel.

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Modelling of Cooling Load in Close-System Solar Greenhouse Under Thailand Climates Using TRNSYS

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Abstract: The solar plastic greenhouse has been widely used in advanced agricultural and horticultural applications owing to its effect on increasing production and high quality of crops. The plantation of winter season fruits and vegetables might be the challenge in growing tropical and subtropical regions. The greenhouse can be generalized into two groups i.e. open system and closed system. The open system is those using sunlight, exposed to the environment and unlimited air change with the surrounding. The closed system which is provided with artificial sunlight and limited air change. The open system has a limited capacity for weather control. On the other hand, the closed system has full control of weather conditions. The purpose of this study is to investigate the cooling load of close-system solar greenhouse in four different locations of Thailand that are Northern, North Eastern, Central and Southern part. The internal temperature of the greenhouse is assumed to be fixed at 15˚C. Thermal insulation materials of walls and roof are 4-mm SCG Smartboard™ and 10-mm AERO-ROOF™. Using TRNSYS simulation software, the solar greenhouse cooling load of the different places can be estimated and discussed. Comparison of the daily greenhouse cooling load difference between four sites is also described. The results would be an important role in reducing the cooling load of the solar greenhouse in future work.

Keywords: Solar greenhouse, closed system, cooling load, thermal insulation materials, TRNSYS software

1 INTRODUCTION

Greenhouses have been widely used from the 17th century until now for various purposes, especially for growing plants and crops. Present day, the greenhouses were built with glass and plastic film providing some ventilation system. The greenhouses have been upgraded with some facilities by creating the environment for plants to generate desirable growing conditions. Due to the demand for high production of crops and reduce the risk of lost crops, greenhouse cultivation becomes common worldwide. The greenhouse can provide appropriate growing conditions through insulation, ventilation, etc., throughout the year in spring, summer, and winter (Zhou, Yu, Yi, & Liu, 2017). Compared to open field cultivation, a modern greenhouse design can yield a high degree of climate control and protect indoor crops from unfavorable ambient conditions changes such as temperature, humidity, solar radiation, etc. Therefore, optimization of greenhouse design requires to take into account these parameters to balance the return of the yield and the related capital and operational costs (Candy, Moore, & Freere, 2012).

Some of the main advantages of the closed greenhouse are that it can improve energy efficiency, production rate, control of the system, total efficiency of the system, sustainable management and reduction of operation costs and rate of waste crops. Greenhouses are categorized into conventional, semi-closed, partly closed and fully closed greenhouse. A conventional greenhouse is the one which exposes to the natural environment, direct sunray and open windows for ventilation. Semi-closed and partly closed greenhouses seem to be similar. However, the semi-closed greenhouse is 'almost' closed greenhouse where part of the cooling demand will be supplied by open ventilation windows, while partly closed greenhouse includes a closed and a conventional area with the energy demand for the conventional part being supplied by the closed portion. (Vadiee & Martin, 2012)

To do the fully closed system greenhouse, facilities such as cooling, heating, ventilation, shading, and insulations have been considered as essential features. Heating in the building is common and straightforward although cooling stands as a challenge in the hot climate of tropics and subtropics regions. Many researchers have studied of the insulation of the greenhouse which is also one of the essential parts to minimize the heat load when the outside temperature is high or maximize when the outside temperature is extremely low. The function of the high thermal insulation material is to reduce the heat transfer rate by covering all the surfaces of the building or greenhouse. The lower thermal conductivity value of the material, the better and higher heat insulation is. Y. García-Alonso et.al (2006) studied new cool plastic films as covering material for greenhouse in Tropical and subtropical areas. The experiment was carried out in Spain for the pepper growing. The results were finally compared by using two types of plastic film (CA-2231C & 2704FM) namely cool film and reference film, both monolayer, 200 micrometers thick. It can be generally concluded that cool film has better results such as increased height of the plant and produce fewer waste fruits. (García-Alonso et al., 2006)

New aerogel super-insulation material for building was investigated to attain energy conservation and cost-effectiveness (Huang et al., 2020). The office building was chosen as a model in a humid subtropical climate. Aerogel had a minimum optimum thickness of 3.7 mm as a result. Additionally, the super-insulated aerogel is compared with four commonly used insulation materials, i.e., expanded polystyrene, extruded polystyrene, foamed polyurethane, and glass fibers. The annual cooling and the heating load for the hollow shale brick building were reduced by 7.5% and 18.2%, respectively when the new aerogel was applied.

Solar Photovoltaic (PV) systems was applied for strawberry in the greenhouse (Hosseini-Fashami, Motevali, Nabavi-Pelesaraei, Hashemi, & Chau, 2019). They studied the utilization of PV and Photovoltaic/Thermal (PV/T) which capture the remaining energy and removes waste heat from the PV module. It is simulated by TRNSYS software as another energy supplier in the "energy-environmental life cycle assessment (E-LCA)" of greenhouse strawberry production in Alborz province, Iran.

Solar greenhouse inside conditions such as air temperature, relative humidity, CO_2 concentration, and solar radiation was simulated using TRNSYS 15 simulation software (Dalamagkidis, Saridakis, & Kolokotsa, 2014). Using this method, it is possible to simulate any greenhouse structure by providing the required information. The greenhouse model was designed with several components which are floor, glazing, plant, and equipment. In the whole model, the

zone component is compulsory which plays as the main component and provided for the output.

From the literature reviewed, it was found that there were no studies on cooling load of solar greenhouses. Cooling system is very essential for keeping inner air conditions as required by plants. Therefore, the main aim of this study is to computationally assess cooling load of a greenhouse that to be built in Thailand. Major concerns for cooling load of the greenhouse is the environment conditions. Therefore, weather data of 4 major cities of Thailand are used in the simulation.

2 METHODOLOGY

This study employs simulation tool "Transient System Simulation or TRNSYS" to study cooling load that is transferred into an insulated space. TRNSYS was chosen due to its well known for high accuracy simulation tool. One-year weather data of 4 regions of Thailand were used. Location of the 4 cities representing the 4 regions are shown in Figure 1.

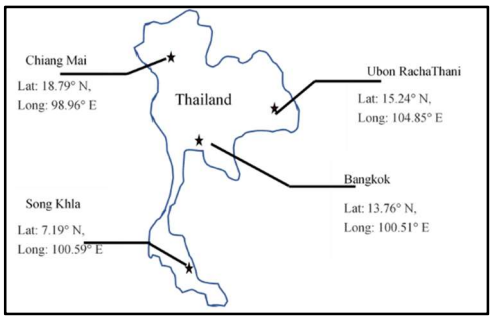

Figure 1: Location of 4 Regions in this study

2.1 Physical Model Setup

Figure 2 shows the physical structure of the stuided greenhouse. The greenhouse was made of aluminium frame and covered with plastic film as shown in Figure 2(a). The overall greenhouse size is 6 m long and 5 m wide with a east-west orientation, and 3 m height. The greeenhouse is equally divided into 3 seperate rooms. The size of each room is 2x5x3 m (WxLxH) (shown in Figure 3). Only on room was used in this simulation (room 1). The simulated room's walls and roof was fitted with SCG (Siam Cement Group) smartboad and AERO-ROOF™ for thermally and insolation insulation, as shown in Figure 2(b).

(a) Design of the greenhouse

(b) Installation of SCG smartboard and AERO-ROOF™ insulation

Figure 2: Structure of the simulated greenhouse

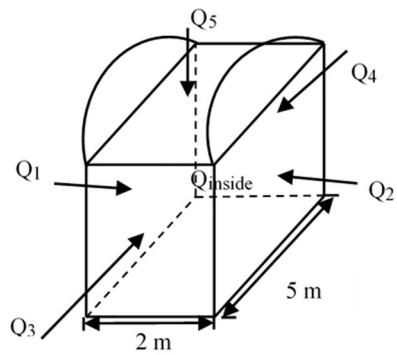

Figure 3: Dimension of the greenhouse

Thickness of SCG Smartboard is 0.4 mm and its thermal conductivity is 0.14 W/m-K. The smartboard consists of SCG Portland Cement brand, silica and special cellulose fiber making through the autoclave process. Color of the smartboard is white. AERO-ROOF™ was fitted by glue on the internal side of the smartboard to minimize air gab thermal resistance. The insulation sheets (3/8-inche thickness) color is black. Its thermal conductivity is 0.035 W/m-K.

2.2 Mathematical Model

Figure 3 illustrates the heat balance of the studied greenhouse. Interaction between the surrounding environment and inside of the greenhouse is shown. The heat transfer through the building envelope that is walls, roof, floor, windows, doors etc. can be considered as external load. Heat generated by occupants, equipment, and lights are called internal load. The percentage of external versus internal load varies with building type, site climate, and building design (ME, 2010).

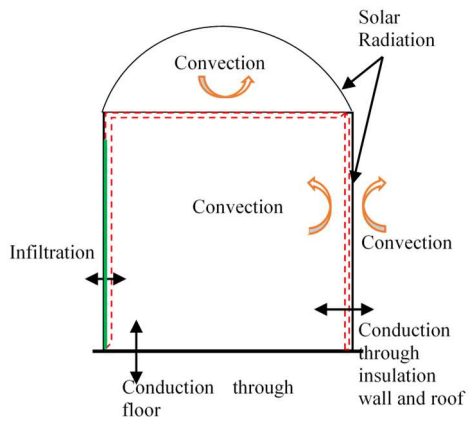

Figure 4: Schematic view showing heat transfer reaction considered in the greenhouse model

Solar radiation presents the main energy input to the greenhouse. Nevertheless, in this study solar radiation will not directly reached into the inside of greenhouse because the greenhouse was fully covered with insulation materials. The heat energy coming through from the environment to the internal of the greenhouse can be calculated by following equations. Q_{inside} is the total heat gain or loss inside of the greenhouse. In this study the Q_{inside} represents the cooling load.

$$Q_{inside} = Q_{surface\_all} + Q_{inf} \quad (1)$$

$$Q_{surface\_all} = Q_1 + Q_2 + Q_3 + Q_4 + Q_5 \quad (2)$$

$$Q_{inf} = \rho \times c_p \times N_{inf} \times V \times (T_{out} - T_{in}) \quad (3)$$

The cooling load composes of two terms, which are $Q_{surface\_all}$ (the heat transferred from the outside through all wall surfaces) and Q_{inf} (the heat gain or loss from infiltration). Heat gain from infiltration can be calculated by equation 3, where ρ is the air density (kg/m^3), c_p is specific heat capacity of air (kJ/kg-K), N_{inf} is number of air exchange per hour of infiltration (h^{-1}), V is the volume of the greenhouse (m^3), T_{out} is the outside ambient temperature (K), and T_{in} is the internal air temperature (K).

The heat transferred from the outside through all wall surfaces are from solar radiation from the sun (Q_{rad}), convection of heat transfer from the environment (Q_{conv}), see Figure 4. Then, the heat transferred to inside of the room through heat conduction (Q_{wall}), see equation 4. The heat conduction through the wall can also be quantified using thermal resistance network as shown in Figure 5.

$$Q_{rad} + Q_{conv} - Q_{wall} = 0 \quad (4)$$

$$Q_{wall} = UA\Delta T \quad (5)$$

$$U = \frac{1}{\frac{x_{SB}}{k_{SB}} + \frac{x_{AR}}{k_{AR}}} \quad (6)$$

A is the area of the surface of the wall (m^2), ΔT is the temperature difference between the outside and inside surface of the wall (K), x is the thickness of wall material(mm) and k is thermal conductivity of the material (W/m-K). The subscripts *SB and AR* stand for smartboard and AERO-ROOF™ respectively. The overall coefficient, U (W/m^{2}K) can be calculated by using equation 6.

In the simulation, the outside wall surface is exposed to solar radiation and surrounding ambient temperature while the internal wall surface is exposed to indoor room air which is maintained at desirable constant temperature. In the simulation the inside air temperature is set at 15°C.

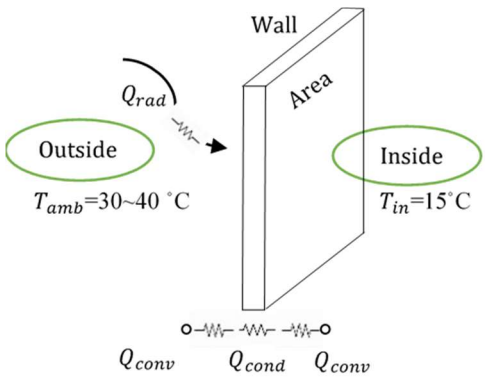

Figure 5: Schematic for heat transfer process

Q_{floor} can be negligible in this case because temperature of the ground floor is relatively too small. Ventilation system is not provided in the controlled greenhouse room.

2.4 Simulation Software

Transient System Simulation (TRNSYS) is simulation software which is first developed at the University of Wisconsin-Madison. It is a reliable program for dynamic transient analysis of renewable energy and thermal energy systems. TRNSYS has been widely used to simulate solar energy applications, conventional buildings, and

even biological processes. It can be used to model new energy concept, from simple domestic hot water systems to the design and simulation of buildings and their equipment, including control strategies, occupant behavior, alternative energy systems (wind, solar, photovoltaic, hydrogen systems), etc.(Trnsys 18, n.d.) The functions include analyzing the thermal performance of buildings, optimizing the operation of a solar thermal system and modelling a hybrid PV-thermal solar system.

The developed greenhouse model is described in Figure 6. Firstly, the building was constructed by choosing the geometry orientation of the greenhouse. The next step was to put the dimension of the greenhouse i.e. area and volume. The meteorological data of each site is added to the weather data component. In TRNBuild, the lighting, heating, cooling, infiltration, ventilation and internal gains are available for the users. The layer such as brick, concrete, gypsum etc. can also be created for wall material. The necessary output data can be added or deleted later based on the user demand.

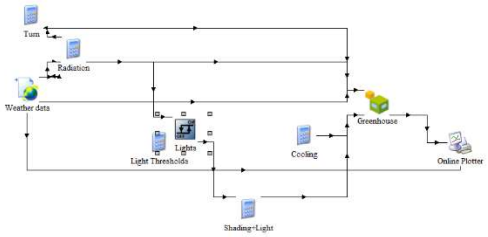

Figure 6: The greenhouse components model using TRNSYS

This study greenhouse model is built from multizone component Type 56 which is linked with weather data of four provinces for simulation of greenhouse cooling loads. The TRNSYS simulation greenhouse model contains a various number of components, including weather data, solar radiation, shading, cooling, multizone building as well as an online plotter. The shading component can be turned on or off if it is not necessary to use. The cooling component is provided for cooling system of the greenhouse. All the necessary heating system, cooling system, infiltration types and ventilation types can be updated in TRNBuild. The information of wall materials that is utilized in the greenhouse has been defined in the greenhouse model. The output data is plotted by using online plotter (Type 65a).

3 RESULTS AND DISCUSSION

In general, solar radiation levels in all 4 cities are high in summer (February to July) and low in raining and winter seasons (August to December) as can be seen clearly in Figure 7. Note that the solar radiation is indicated with caption IT_H, which means solar radiation that reaches horizontal plane. The maximum solar radiation is observed in Chiang Mai during April and May. The lowest sola radiation is observed in Songkhla in November and December. In terms of average temperature, Bangkok and Songkhla shows uniform ambient temperature throughout the year. For Ubon Rachathani and Chiang Mai, the ambient temperature can change from 22°C in winter to 29 °C in summer.

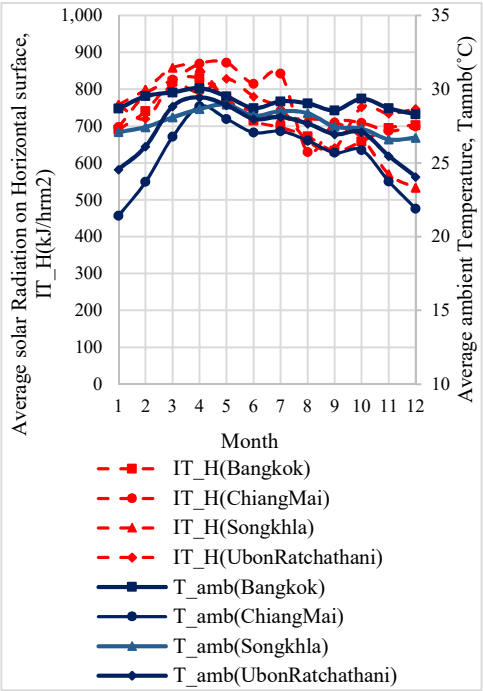

Figure 7: Average solar radiation on horizontal surface and average ambient temperature of four regions

Monthly averaged daily cooling load and monthly average daily ambient temperature of greenhouse from the simulation are shown in Figure 8. In general, average daily cooling load are the highest in April in every city. On the other hand, the average daily cooling load is the lowest in December and January.

For the comparison of average cooling load, the results indicate that cooling load of greenhouse in Bangkok is highest in April (4,100

kJ/hr) compared with the other three regions. In January the lowest daily cooling load is nearly 2,000 kJ/hr in Chiang Mai.

Both the average ambient temperature and average cooling load follow the trend. All of the lines gradually rise until April and slightly go down and go up again in October and dropped at last two months. This implies that the ambient temperature affects the calculated cooling load more than the solar radiation.

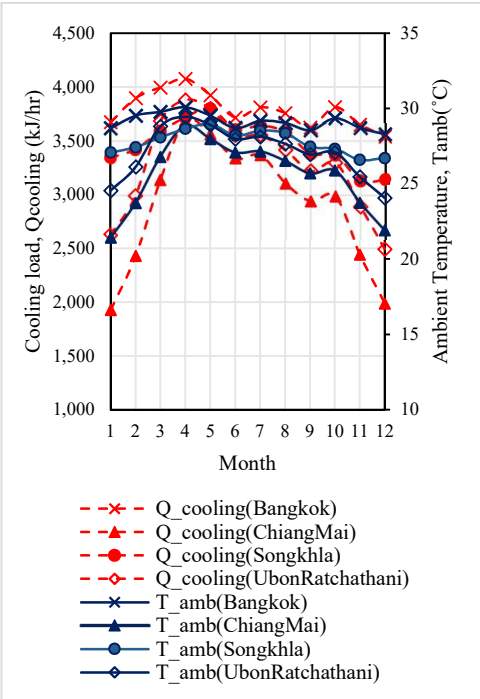

Figure 8: Average cooling load and ambient temperature of four regions

The calculated daily cooling load is maximum in April for Bangkok, Chiang Mai and Ubon Ratchathani while it is maximum in May for Songkhla. It is clear that lattitude of the city affects the level of solar radiation in each month. Songkhla is in the south of Thailand. From Figure 1, the lattitude of Songkhla is 7.19°N. The lattitutes for the other 3 cities are in the same range.

The most siginificant inclination is cooling load of Chiang Mai. The reason is that the outdoor ambient temperature becomes low for early months of the year. Hence the cooling load inside the greenhouse is low (2,000 kJ/hr). The ambient temperature is maximum in April and the cooling load is maximum (3,600 kJ/hr).

Typical hourly cooling load of everyday in each city can be shown in Figure 9. The hourly cooling load increases as the ambient temperature increases. The clculated coooling load is peak when the ambient temperature is the highest, generally at noon. The calculated cooling load decreases in the afternoon, gradually descend at nighttime, and reaches the lowest in the morning of the next day.

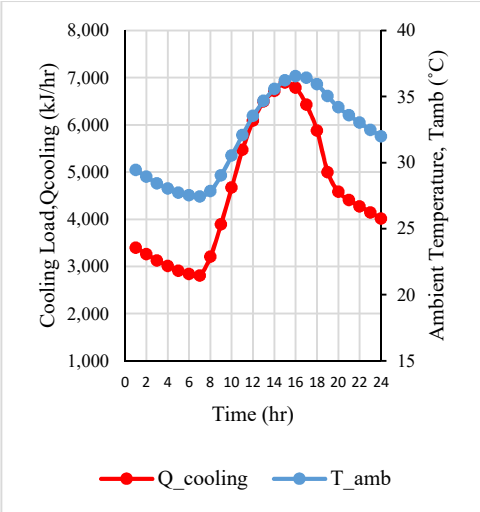

Figure 9: Cooling load and ambient temperature for the period of April 9th to 10th in Bangkok

Figure 9 also provide a key information of the maximum hourly calculated cooling load of Bangkok, nearly 7,000 kJ/hr, which occurs on the 10th April. This is significant information in terms of cooling system design. If such room is to be constructed and installed in Bangkok, cooling system must be sized to deal with this calculated cooling load.

4 SUMMARY

In this study, the solar greenhouse model was developed using TRNSYS. The TRNSYS greenhouse model is used to simulate the cooling load requirement inside the greenhouse 4 cities in Thailand. Maximum and minimum calculated hourly cooling load can be obtained from the simulation. The information can be used for selection of cooling system for the greenhouse. Experiment tests of the same greenhouse configuration will be carried out Chiang Mai.

Results from the experiment will be used in validation of the developed model.

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Anaerobic Digestion of Starch Wastewater: The Long-term Monitoring

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Abstract: In this study, Semi-continues stirred tank (CSTR) was developed and studied on biogas production and methane (CH_4) production from anaerobic digestion of cassava wastewater. The experiment was carried out at mesophilic temperature (35 ± 2 °C) at different OLRs of1.0, 1.30, 1.70, 2.20 and 2.87 kg COD/m^3-day. The results obtained in this work indicated that the optimized performance of reactor was at OLR 2.20 kg COD/m^3-day with the methane yield of 0.47±0.07 NL/g VS_{added}. The reactor showed signal of failure at a high OLR of 2.87 kg COD/m^3-day. The organic acid accummulation may play a key role in this phenomena. An anaerobic digestion of casava wastewater using CSTR reactor is appropriate for co-digestion with the high-nutrient substrate such as animal manures.

Keywords: Anaerobic Digestion, Methane yield, Volatile fatty acid, Organic loading rate, Cassava starch wastewater

1 INTRODUCTION

Thailand is the second largest exporter of cassava starch production, at the same time, exporting the products to the world, wastewater management of the starch factory is a key important issue (Cheah et al., 2019). Similarly, concerning the energy supply is the most concern in the production chain too, thus, the appropriate renewable energy policy is an approach to address this issues. The potential of biogas from cassava starch wastewater is a factor that needs to be taken seriously. In recent years, anaerobic digestion (AD) has become one of the most attractive renewable energy pathways (Ward et al., 2008). AD converts organic materials into biogas, a renewable fuel that could be used to produce electricity, heat or as vehicle fuel.(Scarlat et al., 2018). Biogas production from AD plays an important role to reduce greenhouse gas emission (GHG) which are derived from the use of fossils and, in fact, the use of sustainable resources (Wang et al.,2012). Traditional gas from AD was the methane (CH_4) (55-70%) and carbon dioxide (CO_2) (50-60%) (Sawatdeenarunat et al., 2018). Consistent with the current global environmental situation, which has a strong attention on energy consumption, as well as debates on food and energy issues, which are a hot topic for sustainable development goal, AD could potentially address these problems. Using AD system for waste treatment processes are able to make the most value of the economic and environment, chiefly the use of sustainable energy (Sawatdeenarunat et al., 2015). For example, factories that have direct discharges wastewater to the environment are very harmful to the human and environments, nevertheless, in the event of wastewater was treated by the AD system, we reduce the environmental pollution, access to energy for processing in the factory, including fertilizer for agriculture (Yenigün et al, 2013).The renewable energy has continuously increased using in Thailand because of important approaches, policy, technology, and subsidy. Thailand, the national alternative energy development plan aims to increase the production of alternative energy in the country in order to increase the alternative energy share of the total energy consumption to 30% by 2036 (Damrongsak et al.,2017). One of those, AD of starch wastewater is very promising for renewable energy in Thailand. The AD system in Thailand has been growing annually, with the number of biogas power plan 1,788, which provides overall biogas capacity by 1,405.58 million m3/year (Saengprajak et al.,2019). Nowadays, many researchers will focus on the production of biogas using different condition and substrate (Sang et al., 2019). Base on Prachayawarakorn (2019) reported that starch has been extensively studied for many years in the renewable energy field and it is the most important polysaccharide polymer used to develop biodegradable. Moreover, cassava was developed as an energy crop, producing bioethanol as an alternative fuel, since Thailand is the energy importer net (Piyachomkwan at el., 2011). In order to achieve the purpose of obtaining the appropriate energy product, it is important to take into excuse the overall performance of the system. The performance of AD process has many factors that we need to consideration such as feedstock characteristic, reactor design and operation condition. Among of those, the organic loading rate (OLR) is an important parameter because it indicates the amount of volatile solids to be fed into the digester each day (Babaee et al 2011). However, a high OLR results in the accumulation of volatile fatty acid (VFA) and ethanol, uneven distribution during stirring, and poor transfer of heat that could eventually lead to an irreversible failure (Liu et al., 2017). If large variations of the daily organic loading rate to the biogas occur, this will result in variable rates of gas production. Whilst this is often not a real problem with regard to process stability, it can result in decreased productivity of the biogas plant (Drosg, 2013).The aim of study was investigated the effect of OLRs on the performance of an anaerobic CSTR - of starch wastewater.

2 MATERIAL AND METHOD

This study was conducted at the Energy Research and Development Institute–Nakornping Chiang Mai University.

2.1 Wastewater characteristic

The cassava starch wastewater used in this experiment was provided by starch floured factory from Kamphaeng Phet province. The wastewater was stored in the temperature controlled room at 4±2 °C, and every 3 months the wastewater was recollected from the factory. The

characteristics of cassava starch wastewater are given in table 1.

Table 1: The characteristics of wastewater

Parameter	Value
pH	3.93±0.12
VFA (mg/L)	5,296±292
TCOD (mg/L)	47,427±6,300
FCOD (mg/L)	21,148±3,876
TS (mg/L)	36,911±5,686
VS (mg/L)	33,696±6,114
TKN (mg/L)	785±65
TP (mg/L)	157±23

2.2 Inoculum

Inoculum was collected from the commercial anaerobic digester treating cow manure in Lamphun, Thailand.

2.3 Continuous stirred tank reactor (CSTR)

The lab-scale CSTR was made of stainless steel class 304 with total volume of 9 L and effective volume of 7 L. Mesophilic condition was controlled for this operation (35±2 °C).The gas pipe was connected at the top of reactor and collecting biogas into the aluminum foil gas bag. The diagram of lab-scale CSTR was presented in figure 1.

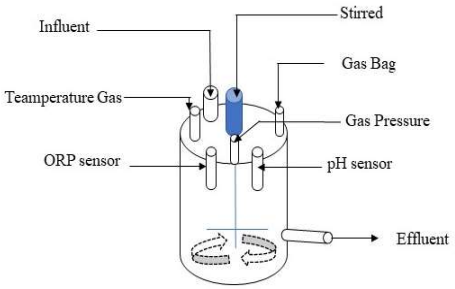

Figure 1: The diagram of CSTR

2.4 Experimental conditions

The experimental plan is presented in table 2. The reactor was operated and monitored daily for more than 200 days, including start up period. The lab scale CSTR reactor was seeded with 2 L of inoculum and 5 L of water. The organic loading rates (OLR) was set at 1.0, 1.30, 1.70, 2.20 and 2.87 kg COD/m^3-day by adjusting feeding flow rates of starch wastewater table 2.

Table 2: The experimantal conditions

OLR (kg COD/m^3-day)	Q (L/day)	HRT (days)
1.00	0.149	47
1.30	0.194	36
1.70	0.252	28
2.20	0.327	21
2.87	0.425	16

2.5 Analytical Method

The performance of lab scale CSTR was investigated at OLR of1.0, 1.30, 1.70, 2.20 and 2.87 kg COD/m^3-day . The influent and effluent were analysed for pH, total COD (TCOD), filtered COD (FCOD), alkalinity (Alk), total solid (TS), volatile solid (VS), suspended solid (SS) and volatile suspended solid (VSS), following the Standard Methods (APHA, 2012), while VFA of the effluent were determined using direct titration method (Dilallo and AlbertSon,1961). The biogas composition was analyzed using a portable gas analyzer. The steady state conditions were considered to achieve when the standard deviation of methane yields were less than 15%.

2.6 Statistical analysis

All results were analyzed and differences among results from different experiments were tested using IBM SPSS Statistic 26. Analysis of variance (ANOVA) and the Tukey's test was performed at a significance level of 5% (α = 0.05).

3 RESULTS AND DISCUSSION

3.1 Production of VFA and pH

pH is the determination of the acidic or alkaline (basic) of the reactor contents. pH is one of essential parameters used to control AD process stability coupled withVFA and alk (Bakraoui et al., 2020). During AD process, the recommended pH force rang is 6.8 to 8.2 (Wu et al., 2019). pH level in this study i.e. 7.11 ± 0.11 was in the recommended range for AD. pH changing is an indicator of the reactor

performance. In addition, VFA fluctuations are also an important factor to pay attention to. The level of VFAs is one of the important parameters that directly affect the process performance, causing the system upset or failure, depending on its concentration (Jiraprasertwong et al., 2019). Figure 2 shows pH and VFA of the effuent at each operating OLRs. Due to VFA accumulation, pH continuously dropped until reaching 6.96±0.18 at OLR of 2.87 kg COD/m^3-day with VFA high as 1,102.77±537.19 mg/L which cause the reactor failed. However, it is not only the high VFA could fail AD reactor but the VFA/Alk ratio are also was observed. The mean values of the VFA/Alk ratio were within the optimum range of operation <0.4 The average of VFA/Alk ratio value for this research was 0.1 which is the appropriated condition for operation range value, also the average VFA/Alk ratio of 0.87 which cause the reactor failed in OLR 2.87 kg COD/m^3-day too. The previous study from Lu et al., (2019), anaerobic digestion of cassava stillage, was reported that the OLR increased, the concentration of VFAs increased greatly, the highest VFAs concentration in reactor with the maximum acetic acid level reached 1524.64 mg/L and would damage the performance of the reactor.

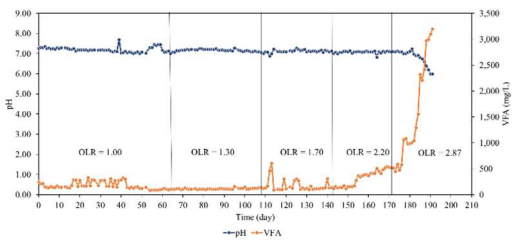

Figure 2: pH and VFA value with OLR

3.2 The efficiency of the reactor

The TCOD removal is an important indicator of AD process Figure 3 presents the average TCOD, FCOD, VS removal at the operating OLR. By increasing OLR from 1.0 to the maximum OLR of 2.87 kg COD/m^3-day, the result presented that at OLR of 2.20 kg COD/m^3-day show the high performance of the reactor. The COD removal efficiency decreased when OLR was increased. Figure 3 was showing that COD removal efficiency was slightly decreased from 94 % to 83 % when OLR was increased from 1.00 to 2.20 kg COD/m^3-day, respectively.

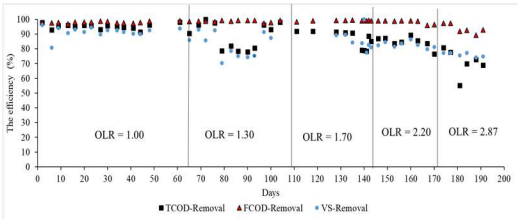

Figure 3: The efficiency of reactor performant

In contrast, Watthier (2019) was to evaluate the treatment of cassava starch wastewater in a horizontal anaerobic fixed bed reactor to the removal of organic matter and generation of biogas from cassava starch extraction with different types of support materials were used: bamboo rings and flexible PVC rings reported that the COD removal efficiency increased with the OLR increase in resulting COD removal values of up to 99%. This result was getting higher efficiency value of COD removal because of the supported of application was operated in higher organic loading rate (15.1 g.L^{-1}. d^{-1}) and lower hydraulic retention time (0.8 days) in the reactors with bamboo and flexible PVC rings as a support material to achieved satisfactory removals of organic matter. On the other hand, this result lower was compared with Araujo et al., (2018) who was calculated the anaerobic reactor performance of packed-bed and continuous flow from the wastewater of cassava starch extraction was reported OLR of 2.5, 5.0, 8.0 and 10.0 g L^{-1}d^{-1}. It was evaluated the removal of COD efficiencies 98.4±0.3 % to 98.9±0.3 % at OLR of 2.5 and 10.0 g L^{-1}d^{-1}, respectively. According to the author reported that evaluated configuration under the conditions tested that there was no disturbance regarding COD removal, even with the load changes imposed on the system because of the recent adaptation of the biomass to the effluent. Over time, there was the microbial community maturation, favoring the consumption of these intermediate acids produced.

3.3 Methane yield

Table 3 show the range of OLRs, cassava wastewater was produced at the same methane yield and it was different from several other investigations. The most significant value was showing OLR value which is appropriate for methane yields in the stage of OLR 2.20 kg COD/m^3-day. The significant (p-value ≤ 0.05) for methane yield showed an increasing tendency, in relation to the increase of OLR value. Methane

yield remained that the OLR 2.87 kg COD/m^3-day which the experiment representative process failure 0.36 ±0.08 $NLCH_4$/g VS_{added}, because the increasing of acidifying microorganisms in the reactor. The increase of carbon dioxide in biogas means that the acidifying microorganisms are prevailing on the methanogens which may lead to volatile fatty acids accumulation (Babaee et al., 2011). The table 3 showing that the appropriated condition for methane yield from the Tukey test revealed that the statistical investigation with OLR 2.20 kg COD/m^3-day is the suitable value for good performance of this study with average methane yield 0.47±0.07 $NLCH_4$/g VS $_{added}$.

Table 3: Noramal methane and OLR

OLR (kg COD/m^3-day)	Noramal methane yields ($NLCH_4$/g VS $_{added}$)
1.00	0.51±0.09[a]
1.30	0.49±0.07[a]
1.70	0.48±0.09[a]
2.20	0.47±0.07[a]
2.87	0.36±0.08[b]

Column means the followed by a same latter(s) are not significantly difference according to the Tukey test ($P \leq 0.05$)

4 CONCLUSIONS

Methane yields from cassava was studied using different OLR. There was significant interaction between changed OLR, which played important role to enhance VFA and methane yields from cassava wastewater. The results obtained in this work show the high performance in terms of COD efficiency 83% and methane yield 0.47±0.07 $NLCH_4$/g VS_{added} and suitable OLR for the operating at 2.20 kg COD/m^3-day. The OLR rate which is failed for operate system at a high OLR 2.87 kg COD/m^3-day to put the methane yield at low rate, because of the increasing of acidifying microorganisms in the reactor. The organic acid accumulation may play a key role in this phenomena. An anaerobic digestion of cassava wastewater using CSTR reactor is appropriate for co-digestion with the high-nutrient substrate such as animal manures.

ACKNOWLEDGEMENTS

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Rheological Characterization of Alternative Raw Materials for Biodiesel Synthesis

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Abstract: The potential of used cooking oil (UCO) recycled as biodiesel is known widely. This offer a sustainable solution that could transform waste into wealth thru biodiesel development energy resource. Usage of UCO will reduce environmental pollution and dependence on fossil fuel. With massive numbers of fast food especially involving fried chicken, the used cooking oil from this industries could potentially be the indirect sources of biodiesel. Therefore, this paper investigate the characteristic of biodiesel derived from used chicken cooking oil (UCCO). The quality and suitability of biodiesel to be produced depending on certain parameters such as kinematic viscosity, density and free fatty acid composition. The quality control was performed under EM 14214 standard and ASTM D6751-08. The present paper attempts to review methods for the transesterification of used chicken cooking oil and new cooking oil (NCO). The paper also examines the basic rheology of the UCCO derived biodiesel that might effects of the products formed in the frying process on biodiesel quality.

Keywords: Used fried chicken cooking oil, Biodiesel, kinematic viscosity.

1 INTRODUCTION

Biodiesel is an alternative fuel produced from domestic renewable resources. It has not been utilized widely around the world due to the high cost of raw materials. In order to overcome this, usage of lower quality oils such as used cooking oils or animal fats that being produced in excess of food processing industries could be a solution. This will also help to reduce the problem of used oil disposal (Zhang *et al.*, 2003).

Used cooking oil is known as the end product of frying foods using cooking oil that contains either plant or animal fats that undergo certain processed. Cooking oil is glycerol ester that consists various type of fatty acids (Alias, Jayakumar and Md Zain, 2018). Two types of cooking oil refers to plant base lipids such as canola oil, palm oil, coconut oil, soybean oil, olive oil or lipid-based animals, such as butter and ghee (Patel *et al.*, 2019). This used cooking oil is categorize as fat and grease and stay in liquid shape at room temperature. It is produced by food industry, food premises and household as a result form preparing the food. However, due to its insoluble property with water, it generates contaminants to the environment.

The repeated usage of cooking oil is dangerous to consumers due to the toxic such as peroxides, aldehyde and polymer through several reactions such as thermolytic, hydrolysis, and oxidation (Hanisah, Kumar and Ay, 2013) especially when the oil is oxidized from fried food. Meanwhile the direct discharged of used cooking oil will result in pipes clogging and destruction towards septic system and waste water (Nor Athirah *et al.*, 2016). Used cooking oil has great potential to be commercialized as it can be used in the production of products such as biodiesel. It is an alternative towards edible oil as source to produce biodiesel, that lead in reduction of the unnecessary increasing demand of deforestation for plantation (Yaakob *et al.*, 2013).

The main objective of this paper is to understand the potential of used chicken cooking oil (UCCO) derived biodiesel and compared with the new cooking oil (NCO) derived biodiesel to look for their suitability as feed stock for biodiesel preparation. It involve the study on viscosity, density, percentage of biodiesel yield and checking on free fatty acids.

2 MATERIALS AND METHODS

The UCCO was collected from school canteen in Tangkak, Johor, Malaysia. The usage of the oil was control up to three time only. In order to remove insoluble impurities, the oil was filtered and heated to remove moisture. All the chemicals used were of analytical grade and purchased from Sigma-Aldrich, except as noted otherwise.

2.1 Pre-treatment of UCCO

Pretreatment of the UCCO is needed because the acid number of this oil was greater than 1 mg KOH/g. It is also important to match the oil characteristics before the transesterification process. The process started with 1 litre of UCCO being heated for 15 – 30 minutes at 65 °C and was let to settle for 24 hours. The FFA values were determined as soon the water has been removed thru vacuum evaporation. The FFA value was calculated using the relation shown in Eq. (1):

$$\text{Free fatty acid conversion (\%)} = \frac{A_i - A_t}{A_i} \times 100 \quad (1)$$

Where, A_i and A_t, refer to the acidity (at zero and time, t)

2.2 Transesterification process

Transesterification process started with dissolving a 10 g of KOH pellets into a 260 ml of methanol in 500 ml beaker. The methanol to oil ratio used was 6:1 ratio. The beaker containing Potassium Methoxide was covered with aluminum foil to avoid evaporation of methanol. Then, UCCO was once again heated up to 55 °C and poured into the conical flask followed by the potassium methoxide prepared earlier. The mixtures was mixed for 20 to 30 minutes at suitable speed. Then, it was poured into a 2 liter separating funnel. The separating funnel was caped and labelled as UCCO. The oil was let to settle for 24 hours. After 24 hours of settling, two immiscible layers were observed in the separating funnel. The darker color known as glycerin and the biodiesel in clearer color. After draining off the glycerol, the biodiesel was washed three times with 1:1 volume of water to remove excess methanol and catalyst.

2.3 Kinematic viscosity (ASTM D7042)

Spindle Type I and Brookfield Dial reading Viscometer have been used. A total of 250 ml of UCCO derived biodiesel were used and value of speed was set at 30.00 rpm. The sample was heated at 25°C, 40°C, 60°C, 80°C, and 100°C. Average value of the kinematic viscosity of UCCO derived biodiesel was calculated based on three times repeated test. This test was repeated with (NCO) derived biodiesel.

2.4 Density measurement

A Mettler Toledo density meter was used in this study. The density also replicating the same temperature of kinematic viscosity. The reading was taken triple times.

3 RESULT AND DISCUSSION

3.1 FFA content

Determination of FFA content is important in order to choose between alkaline catalyst or acid catalyst for transesterification process (Kulkarni and Dalai, 2006). If the FFA contents is high (>1 wt %), acid catalyst is suitable, while for a range of <1wt% and <0.5 wt %, alkaline catalyst is preferable for the process. A normal amount of free fatty acid on the waste cooking oils is about 2% w/w (Marchetti, Miguel and Errazu, 2007). The FFA content for UCCO is 1.46 wt %, thus the catalyst used is acid base, while for NCO with 0.8 wt %, alkaline base is chosen as shown in Table 1.

Table 1: Free Fatty Acid (FFA) Contents Before and After removal

Sample		Before removal	After removal
UCCO	FFA %	2	1.46
	FFA (% removal)	27	
NCO	FFA %	1.2	0.8
	FFA (% removal)	33.33	

Meanwhile, looking at the biodiesel yield percentage as stated in Figure 1, UCCO produced less reaction yield percentage, with 82.5 % as compared to NCO with 96.4 %. This might due to repeated usage of the UCCO leads to deterioration of oil quality which can lead to reduced ester yield during biodiesel production and the formation of unwanted products (Kulkarni and Dalai, 2006). Another possible reason is the inefficient conversion of UCCO due to high FFA contents. This claim is supported by Ambat et al.,(2018) as they stated that alkaline base catalyst is not efficient for the conversion of oils containing high FFA because FFA will form soap which will inhibit separation of ester and glycerin. Similarly, Sanli et al., (2011) also believed that high FFA content will have negative influence on transesterification.

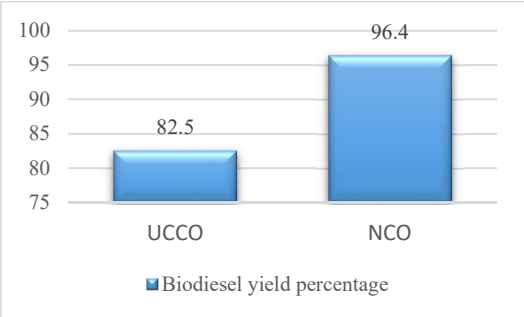

Figure 1: Biodiesel yield percentage of UCCO and NCO.

3.2 Physiochemical properties of biodiesel

The physiochemical properties of UCCO and NCO are given in Table 2. The viscosity of transesterified oil that come from NCO and UCCO are compared with the biodiesel standard ASTM D6751-08 and EN 14214. With the kinematic viscosity of 3.4789 mm^2/s, UCCO is found to be within the range as stated by the international standard while NCO have a bit higher value. The number of kinematic viscosity continuously increases as the fuel quality decreasing, thus this is consider as a good indicator (Saluja, Kumar and Sham, 2016). According to Knothe (2005), based on European biodiesel standard norm, the kinematic viscosity is restricted to 3.5-5.0 mm^2/s. However, The American specifications allow a broader range of values (1.9-6.0 mm^2/s). Meanwhile, the density

for both tested samples were found to be within the standard range.

Table 2: Physicochemical Properties of Standard Biodiesel

Properties	Standard Biodiesel (ASTM D6751-08)	Standard Biodiesel (EN 14214)	Used Chicken Cooking oil (UCCO) biodiesel	New Cooking oil (NCO) biodiesel
Density @ 40°C (kg/m^3)	-	860-900	865	867
Kinematic Viscosity @ 40°C (mm^2/s)	1.96-6.0	3.5-5	3.4789	5.8004
Acid Value (mg KOH/g max)	0.5	0.5	0.947	0.517

3.3 Kinematic viscosity

The variation of kinematic viscosity with temperature between UCCO and NCO is shown in Figure 2. According to this figure, kinematic viscosity keep decreasing as the reaction temperature increase. Narayan and Vaidya, (2016) explained that this is due to the increase of kinetic energy of the molecules and the momentum transfer between molecules dominates over the intermolecular attraction. Therefore, the kinematic viscosity decreases. UCCO derived biodiesel seem to have more stable plot as compared with NCO. It can be seen that, NCO derived biodiesel decrease tremendously at 40°C. The possible reason is due particles bonding where attractive forces are loosen with the increasing of thermal force energy.

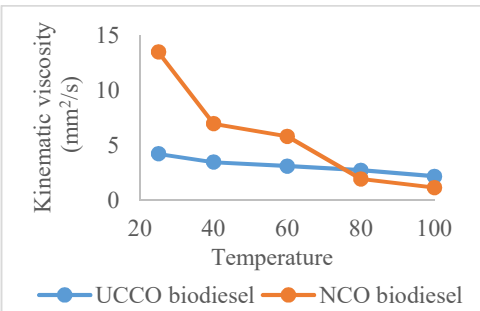

Figure 2: Kinematic Viscosity of UCCO and NCO derived biodiesel.

4 CONCLUSIONS

Depending on type of source on waste generation, UCCO should provide different characteristic that affecting the quality of biodiesel production. From this preliminary study, it shows that the density and kinematic viscosity of UCCO is within the range of the standards quality needed as compared to raw cooking oil biodiesel. However, the biodiesel yield percentage shows that due to possibilities of dirt and impurities occurrence, UCCO has lower yield as compared with NCO. With possible lower cost, and better kinematic viscosity number, UCCO is a better option to replace the usage of raw vegetable oil as the source of biodiesel. Further investigation need to be done to evaluate the tribological behaviour of UCCO biodiesel before it can be used in the engine system.

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Effect of Heat Pretreatment on Biogas Production from PLA Bioplastic and Food Waste

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Abstract: This study investigated effects of heat pretreatment on polylactic acid (PLA) based bioplastic and food waste (FW) degradation for subsequent biogas production. A mixture of PLA and FW sample was heated at 80 °C for 2 and 4 days. The biogas produced from treated samples for 2 and 4 days were 416.58±35.89 mL/gVSadded and 541.84±52.15 mL/gVSadded, respectively. With respect to the control (untreated sample), the reduction in biogas production of 27% and 5% was observed on pretreated PLA and FW samples for 2 and 4 days, respectively. The decrease in methane/biogas generation would be due to high concentration of lactic acid derived from PLA bioplastic hydrolysis with the presence of melanoidin obtained from heat treatment of FW during the pretreatment process

Keywords: Bioplastic, Polylactic acid (PLA), Biodegradation, Heat pretreatment, Melanoidins

1 INTRODUCTION

Due to concerns over environment, bioplastics (or bio-based plastics) produced from renewable resources are widely used to replace non-biodegradable plastics (Comaniţă et al., 2015; Pilla, 2011). Polylactic acid bioplastic (PLA) is the most popular bioplastic currently used globally with the total production equivalent to 10.3% of global bioplastic production (Data, 2017). This bioplastic could be produced through bacterial fermentation of hexose sugars derived from agricultural products for the lactic acid raw material generation (Garlotta, 2001). PLA bioplastic could be used in various sectors for rigid packaging application including, industrial packaging, food packaging, and biocompatible/bioabsorbable medical devices (Vasmara and Marchetti, 2016). PLA production capacity has been expected to continual increase by 5-6 million tons per year, in 2016-2020 (Plastics Institute of Thailand, 2013). Consequently, it is inevitable that the presence of PLA plastic in municipal solid waste has been increasing significantly. Therefore, effective bioplastic waste management is critical for sustainable bioplastic utilization.

PLA bioplastic commonly used as food packages in Thailand and thus, with the current waste separation situation in Thailand, approximately 10% of plastic is certainly mixed with the food waste (FW) (Pasukphun et al., 2019). It is imperative that technology adopted for waste management in Thailand would be able to manage the bioplastic together with the food waste. Although PLA bioplastics are commonly composted, the process requires long time with large space which would not efficient for large scale waste management. There were several attentions for PLA bioplastic waste management trough anaerobic digestion mostly focused on pretreatment condition where temperature is considered as a key factor for PLA degradation (Copinet et al., 2004; Dunne et al., 2000; Ghorpade et al., 2001). The biodegradation of PLA powder (125µm-250µm) in co-digestion with cow manure and vegetable waste reached 60% at thermophilic condition whereas only 2.9% of PLA degradation was observe weekly at low temperature (Yagi et al., 2009). In addition, PLA was rapidly degraded at temperatures higher than its glass transition temperature which is 61 °C. At 65 °C, PLA degraded by 89% in 3 months while under its transition temperature, at 50 °C, approximately 6 months were required to degrade PLA by 89% (Shi and Palfery, 2012). Moreover, study from Wang et al. (2012) showed that high temperature (80°C) could enhance transformation of PLA particles to lactic acid more than the degradation under 55°C.

However, the facilities and technologies of biogas production from bioplastics in Thailand have been limited. Therefore, this study aims to investigate effects of heat pretreatment at 80°C on PLA bioplastics degradation and biogas production from PLA bioplastics in co-digestion with food waste under mesophilic (35°C) anaerobic condition.

2 DETAILS EXPERIMENTAL

2.1 Bioplastic and Food Waste Preparation

In this study, polylactic acid (PLA) bioplastic was used as a substrate. The PLA film was subjected to size reduction to obtain small pieces (<4.75 mm). The organic composition of food waste (FW) often varies with factors such as food availability, seasonal variation and consumption patterns (Li et al., 2017). To reduce experimental bias due to the different composition of FW, FW substrate used in this research was prepared based on an average compositional analysis of FW in Thailand consisting of 65% carbohydrate (rice), 17% vegetable and 18% meat (w/w) (Nathao et al., 2013). FW and PLA samples were mixed with the ratio of 10% PLA and 90% food waste (based on total weight) and used as a substrate for further pretreatment experiment

2.2 Thermal Pretreatment

Thermal pretreatment process was performed in 1-L laboratory glass bottle with working volume of 0.5 L. The sample mixtures including PLA+FW and water were fixed at the total solids (TS) content of 25±5%. The samples were heated at a constant temperature of 80±3°C in an oven for 2 and 4 days. The test bottles were close tightly to reduce water loss during thermal pretreatment. Physical and chemical properties were analyzed before and after the pretreatment process.

2.3 Biogas Production Study

To determine the anaerobic biodegradability of PLA bioplastic in co-digestion with FW, biochemical methane potential (BMP) testes (VDI, 2006) were conducted in 1-L glass bottle with working volume of 0.4 L at controlled temperature (35±2°C) using samples from thermal pretreatment process as a substrate. The control sample without thermal pretreatment was also anaerobically digested. The inoculum used for the BMP tests was from channel anaerobic digester of animal manure wastewater. The substrate to inoculum (F/M) ratio was fixed at 0.5 gVS/gVS. After inoculation, pH was adjusted to 7.0. To create anaerobic environment, the bottles were flushed with nitrogen gas for 3 mins, capped with natural rubber sleeve and sealed with aluminum ring seals. Each sample was performed in triplicates. Biogas volume and composition were daily monitored during fermentation. The biogas volume was measured daily using manometer (KIMO Model MP120, France) and the pressure data collected, were used to calculate the volume of biogas produced. Negative control sample containing only the inoculum was conducted and its biogas production was used to compensate the amount of biogas generated from the inoculum in all experiments. The reported biogas values were normalized into standard temperature and pressure (STP) conditions. Biogas compositions (CH_4, CO_2, O_2, H_2S and N_2) were detected by portable gas check and confirmed by gas chromatography during anaerobic digestion.

2.4 Analytical Methods

Total solids (TS), volatile solids (VS) and chemical oxygen demand (COD) analyses were performed based on the standard methods of the American Public Health Association (APHA, 2012). Concentration of protein was measured by Kjeldahl methods (APHA, 2012). Volatile fatty acids (VFA) was determined using titration methods modified from Dilallo and Albertson (1961). Carbonate alkalinity was determined using titration methods (APHA, 2012). All parameters except VFA and carbonate alkalinity were analyzed before and after anaerobic digestion. VFA and carbonate alkalinity were analyzed only prior to anaerobic digestion.

3 RESULTS AND DISCUSSION

3.1 Effect of Thermal Pretreatment on Physical Property

The thermal pretreatment of PLA+FW samples was done at 80°C for 2 and 4 days. The result showed that physical characteristics of both PLA and FW changed when samples were heated. PLA samples were disintegrated into small pieces but no complete PLA degradation was observed for all samples. During heat treatment, FW was also degraded and changed to brown color. Moreover, organic compounds are liquidized and dissolved into the liquid phase which was in close agreement with the study from Liu et al. (2012) suggested the organic matters release into the soluble form after thermal pretreatment.

The effect of heat treatment on PLA changes was observed by pH monitoring. Heat pretreatment resulted in pH drop. The longer pretreatment time was performed, the more pH reduction was observed. The pH of untreated sample and treated sample for 2 and 4 days were 6.27, 4.96 and 3.25, respectively. The pH reduction was mainly due to soluble organic acid released from organic substances (Jin et al., 2016). Moreover, the organic acid (lactic acid) could be released from degradation of PLA (Kale et al., 2007).

3.2 Effect of Pretreatment of Bioplastic and Food Waste on Biogas Production

The samples (untreated and pretreated) were anaerobically digested. Figure 1 shows the accumulated biogas production during 200 days. Untreated sample (FW + PLA_U) had the highest biogas production of 572.41±59.78 mL/gVS_{added} with 60.3% methane. The biogas productions for 2 and 4 days pretreated samples (FW + PLA_2d and FW + PLA_4d) were 416.58±35.89 mL/gVS_{added} with 57.4% methane and 541.84±52.15 mL/gVS_{added} with 57.5% methane, respectively. The results showed that heat pretreatment at this condition had adverse effect on biogas production. The reduction in biogas generation would be due to the high temperature and long duration time during pretreatment process. Soluble organics were further transformed into melanoidin, the refractory organic component which is undegradable

through biological process, causing the reduction in biogas yield in anaerobic digestion system (Liu et al., 2012).

To confirm the assumption, only food waste samples were heated at 80°C for 2 and 4 days prior to be digested in anaerobic condition. The results showed that untreated FW reached 759.30±34.63 mL/gVS$_{added}$ with 63.1% methane which is higher than pretreated FW (650.41±32.39 mL/gVS$_{added}$ with 59.0% methane and 663.54±20.68 mL/gVS$_{added}$ with 57.4% methane, pretreated for 2 and 4 days respectively). Similarly, untreated FW sample (FW_U) yielded higher biogas than that of the pretreated FW samples for 2 and 4 days (FW_2d and FW_4d).

In addition, the samples were analyzed for the present of melanoidin by spectrophotometry at wavelength of 254 nm (Dwyer et al., 2008). FW samples undergone thermal pretreatment contained higher melanoidin and the sample with longer pretreatment time (FW_4d) had higher melanoidin

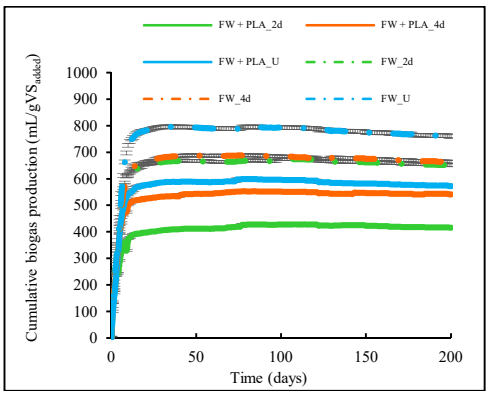

Figure 1: Cumulative biogas production from PLA bioplastic (PLA) in co-digestion with food waste (FW) and food waste (FW) samples at various conditions; U (control sample without heat pretreatment), 2d (sample with heat pretreatment for 2 days) and 4d (sample with heat pretreatment for 4 days).

content than that of the 2 days treated FW (FW_2d). Optical density (at 254 nm) acquired from untreated and treated FW samples for 2 and 4 days were 0.120, 0.462 and 0.520, respectively. The lower of melanoidin content in FW_U sample resulted in higher amount of biogas generated during anaerobic digestion. This result was in close agreement with Liu et al. (2012) who indicated that thermal pretreatment (175 °C/60 min) of kitchen waste and vegetable/fruit residue resulted in melanoidin generation which had a significant adverse effect on biogas production with 7.9% and 11.7% reduction in methane using kitchen waste and vegetable/fruit residue as substrates, respectively.

Moreover, the reduction of biogas production in treated FW + PLA samples would be due to the accumulative of lactic acid oligomers and monomers derived from PLA degradation in heat pretreatment process (Kale et al., 2007). Further experiment investigating the effect of lactic acid on biogas production was performed. FW samples with and without addition of 10 g/L lactic acid (FW and FW + LA samples) were anaerobically digested for 55 days. The results showed the lower biogas production from FW sample with 10 g/L of lactic acid with respect to the FW sample and the resulting biogas produced from FW and FW + LA samples were 790.29 and 492.18 mL/gVS$_{added}$, respectively. This finding was in close agreement with Bo et al. (2007) who reported that high concentration of lactic acid reduced the efficiency of biogas and methane production from food waste. Lactic acid could also be changed to propionic acid, an intermediate in the process of converting organic acids into methane which occur very slowly when compared to the process that used other intermediates such as acetic acid and butyric acid, resulted in propionic acid accumulation and subsequently decreased biogas production efficiency (Ren et al., 2002).

4 CONCLUSIONS

The present research experimentally demonstrated that thermal pretreatment of food waste and PLA during at 80°C for 2 and 4 days would reduce the efficiency of biogas production resulted from melanoidin production and accumulation of lactic acid. For this reason, food waste should not be pretreated at this condition before anaerobically digested. Lower temperature and/or shorter pretreatment duration should be performed to minimize melanoidin formation and complete PLA hydrolysis into lactic acid monomers in the pretreatment process.

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Color and Organic Compounds Reduction in Biogas Effluent of Ethanol Industry by Adsorption Process

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Abstract: Biogas effluent of ethanol industry contains dark brown color due to melanoidin and high concentration of organic compounds after anaerobic treatment. Acceptable color and organic substances measured as chemical oxygen demand (COD) for discharge cannot be achieved without some form of post-treatment. The objective of this study was to reduce color and organic compounds in biogas effluent by commercial activated carbon from coconut shell (GAC-CS). The effects of concentration, GAC-CS dosage and pH value on color and organic compounds removals were determined. The experimental results showed GAC-CS had BET surface area of 1048.43 m^2/g and total pore volume of 0.4505 cc/g. The color and COD reductions of 67.48% and 33.72%, respectively, were achieved at equilibrium using 2 g of GAC-CS, 25% dilution and pH of 2. The GAC-CS equilibrium adsorption is well described by Langmuir isotherm.

Keywords: Activated carbon, Adsorption, ADMI, Biogas effluent

1 INTRODUCTION

The development of renewable energy in Thailand has increased steadily due to intensive governmental promotion policy. In 2014, there are 22 ethanol production facilities with a total capacity of 5.31 million liters per day while the demand of ethanol was 3.25 million liters per day. The ethanol production is expected to increase as the long-term development plan indicates the goal of 11.3 million liters per day by 2036 (AEDP 2015).

Ethanol is produced from molasses (68% of total production), followed by cassava and sugar cane (26% and 5%, respectively) (AEDP 2015). In the production of 1 liter of ethanol, wastewater is generated up to 15 liters (Vivekanandam et al., 2014). The wastewater usually has high COD (60,000-100,000 mg/L) and high BOD (35,000-60,000 mg/L) with a relatively low pH (less than 4.0-4.5) (Satyawali and Balakrishnan, 2007). Wastewater generated from ethanol industries is dark brown in color due to the presence of melanoidin (Liakos and Lazaridis, 2016).

Several methods are used in order to treat the ethanol wastewater such as evaporation or biological treatment like anaerobic digestion. Anaerobic digestion treatment is able to achieve 60–75% reduction of COD (Figaro et al., 2006). However, the wastewater contains a high proportion of phenolic recalcitrant compounds accounting for 33% of the COD content, including gallic acid, melanoidin and tannic acid that are not degradable under anaerobic condition (Kaushik et al., 2017). Biological treatment with certain bacteria and fungi had been applied but the color removal was not satisfactory (Peña et al., 2003). Therefore, it is necessary to study an additional treatment method to remove color and organic compounds from the ethanol effluent.

One possible post-treatment available for biogas effluent of ethanol industry is the adsorption by using activated carbons (ACs) (Satyawali and Balakrishnan, 2007 and Bernardo et al., 1997).

The objective of this study is to reduce color and organic compound in biogas effluent by commercial activated carbon from coconut shell (GAC-CS) and to identify the suitable initial effluent concentration, the sorbent dosage and pH value for the adsorption process. Also, the equilibrium data of the adsorption process were fitted to Freundlich and Langmuir isotherm models to determine the adsorption mechanism of the organic pollutant molecules onto the GAC-CS.

2 EXPERIMENTAL

2.1 Materials

2.1.1 Biogas Effluent Wastewater Collection

Biogas effluent wastewater was taken from Millionaire Suphan Biogreen Power Co., Ltd. (Suphanburi, Thailand).

2.1.2 Sorbent Material

A commercial activated carbon (Granular Activated Carbon from Coconut Shell; GAC-CS) from Pure sorb 830 WC100 ID 1000 was used.

2.2 Methodology

2.2.1 Activated Carbon Characterization

The Brunauer–Emmett–Teller (BET) surface area and pore volume of the GAC-CS were measured by multi-point BET from N_2 adsorption isotherms, using an automated gas sorption system. The morphology of the GAC-CS surface was determined by scanning electron microscope (SEM).

2.2.2 Adsorption Experiment

Each adsorption experiment was carried out in a 250-mL conical flask containing 100 mL of diluted biogas effluent at different dilution ratios, i.e. 10%, 25%, 50% and 75% by volume using distilled water at pH 3. The GAC-CS dosage was varied from 0.25 to 2.0 g. Then the adsorbent-effluent mixture was agitated by a shaker at 160 rpm for 10 minutes. The supernatant was taken after the removal of the suspended activated carbon by centrifugation at 7000 rpm for 15 minutes, followed by vacuum filtration using 0.45 µm filter. The filtrate color was measured in ADMI unit and organic compound was measured as soluble COD. The percentage of color or COD reduction (%R) was calculated as follows (Kaman et al., 2017 and Bernal et al., 2016).

$$\%R = \frac{(C_0 - C_e)}{C_0} \times 100 \quad (1)$$

Where C_0 and C_e (mg/L) is effluent concentration at initial and equilibrium, respectively.

The effects of pH on adsorption experiments were studied in a batch mode using 100 mL of diluted biogas effluent at dilution ratio of 25% at pH 2.0, 2.5, 3.0, 3.5, 4.0 and unadjusted pH (8.0). The selected pH base on Shivayogimath and Inani (2014). Then the suitable GAC-CS dosage of 2 g was added to each conical flask. The adsorbent-effluent mixture was kept agitated in a shaker at 160 rpm for 10 minutes. The supernatant was taken after the removal of suspended activated carbon using the method mentioned earlier.

2.3 Laboratory Analysis

The color measurement was performed according to the ADMI (American Dye Manufacturers Institute) Color Index which measures the transmittance at the wavelength of 400-700 nm, comprising 31 wavelengths with an incremental 10 nm step (Liakos and Lazaridis, 2016). Standard methods for water and wastewater examination were applied for the determination of COD. The closed reflux methods (5220C and D) was used to determine COD concentration of the samples.

2.4 Statistical Analysis

All results were analyzed and differences among results from different experiments were tested using either Student's *t*-test or ANOVA at 95% confidence level.

3 RESULTS AND DISCUSSION

3.1 Activated carbon surface properties

For GAC-CS surface analysis (Table 1), the BET surface area was found to be 1,048.43 m^2/g with the total pore volume of 0.4505 cc/g and average pore radius of 8.59 Å. These characteristics were comparable to the results of Simaratanamongkol and Thiravetyan (2010) who obtained BET surface area of 993 m^2/g with total pore volume of 0.4920 cc/g and average pore radius of 9.91 Å for commercial activated carbon from coconut shell

Scanning electron microscopy (SEM) image (Figure 1) at 200X magnification clearly revealed the surface morphology and porosity in the activated carbon used in this study. As can be seen, the adsorbent contained a large number of micropores mesopores and macropores similarly to the study from Kuman et al. (2017) which found various porosity characteristics on the surface of activated carbon prepared from steam treatment of coconut shell.

Table 1: GAC-CS surface area and pore characteristics

Sample	BET surface area (m^2/g)	Total pore volume (cc/g)	Average pore radius (Å)
GAC-CS	1048.43	0.4505	8.59

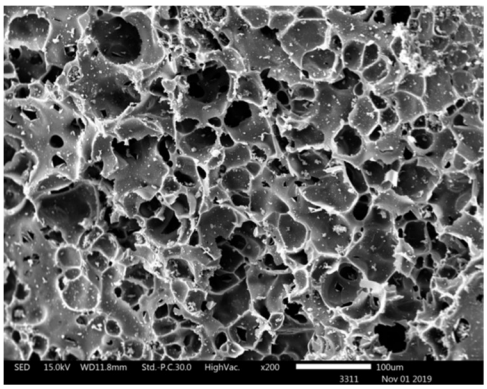


Figure 1: SEM image of GAC-CS at 200X magnification.

3.2 Effects of operation parameters

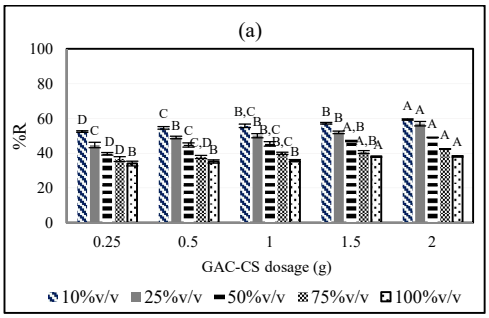
3.2.1 Effects of initial biogas effluent concentrations and GAC-CS dosage

The effect of adsorbent dosage was investigated. It was found that the dose of GAC-CS required depended on the initial biogas effluent concentration. Figure 2 (a) and (b) show the adsorption efficiency of GAC-CS at varying initial biogas effluent concentrations. The reduction of color and COD efficiency decreased with increasing initial biogas effluent concentration due to the limited capacity of GAC-CS to adsorb high amount of pollutants (Kaman et al., 2017). The highest color and COD reductions of 59.36% and 36.49%, respectively, was observed at low initial biogas effluent concentration of 10% v/v and the GAC-CS dosage of 2 g/100 mL. At the higher initial biogas effluent concentration of 25% v/v, the color and COD reduction was lower to 56.98% and 34.35%, respectively. However, at the GAC-CS dosage of

2 g/100 mL, it was found that both color and organic reductions of samples containing initial concentration of 10% and 25% v/v were insignificantly different at 95% confidential level (P=0.086). Consequently, the initial effluent concentration of 25 %v/v and GAC-CS dosage of 2 g/100 mL was chosen for subsequent color and organic compound reduction studies.

3.2.2 Effect of pH

The effect of pH on color and COD reduction is presented in Fig. 3. The results indicated that color and COD adsorption by GAC-CS was favored in an acidic condition (pH 2). The percentages of the color and COD reduction at pH 2 were 67.48% and 33.72%, respectively. The increase of pH from 2.0 to 4.0 and 8.0 (unadjusted pH sample) caused a major decrease in color and COD reduction. The color and COD reduction were comparable to Shivayogimath and Inani (2014) who obtained 62.83% and 95.2% of color and COD reductions at pH 2. The pH value is one of the key factors indicated color and organic compound removal efficiency in adsorbtion process. The increase of pH might hamper the interaction between negative-charged GAC-CS with the negative-charged melanoidin (Liakos and Lazaridis, 2016). This finding was in close agreement with Bernal et al. (2016) who also investigated color removal of beet molasses by ultrafiltration using powdered activated carbon and demonstrated the higher color removal efficiency at pH 3 compared to that of pH 7.



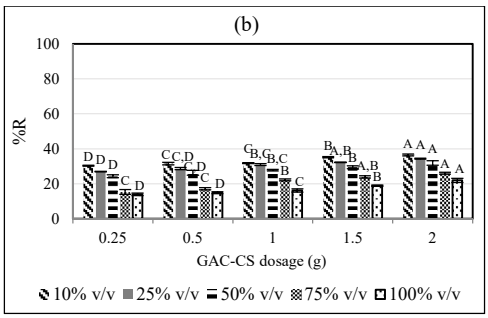


Figure 2: Effect of initial biogas concentration and GAC-CS dosage on the color (a) and COD (b) reduction.
Note: The letters above the bar graphs correlate statistical analyses within each initial effluent concentration.

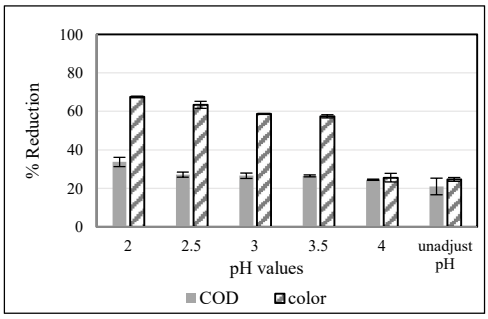


Figure 3: Effect of pH on the percentage color and COD reduction.

3.3 Adsorption Isotherm

The adsorption isotherm indicates concentration distribution between the adsorbent and liquid phases at a particular temperature upon reaching the equilibrium. Isotherm data can be correlated via empirical or theoretical equations following the Langmuir and Freundlich isotherm models which can be defined as following equation 2 and 3 respectively. The GAC-CS characteristics such as adsorption capacity and surface properties can be made known from constants values obtained from each isotherm model (Kaman et al., 2017).

$$\frac{1}{q_e} = \frac{1}{K_L q_m}\frac{1}{C_e} + \frac{1}{q_m} \quad (2)$$

$$\log q_e = \frac{1}{n}\log C_e + \log K_F \quad (3)$$

where q_e is the amount of color adsorbed on GAC-CS at equilibrium (mg/L), C_e is the color concentration at equilibrium, q_m is the maximum

adsorption capacity (mg/g), K_L is the Langmuir constant (L/mg), K_F is the Freundlich constant (L/g), and n is the adsorption intensity.

The adsorption isotherm constants of Langmuir and Freundlich models were summarized in Table 2. From the result, the experimental data fitted the Langmuir isotherm for both color and COD in accordance with the correlation coefficients (R^2). As can be seen, the R^2 value of Langmuir isotherm model is higher than that of Freundlich one. This result suggests that the adsorption of color and organic compounds on GAC-CS adsorbent occurred in a form of monolayer adsorption which was in line with the works of Kaman et al. (2017) and Simaratanamongkol and Thiravetyan (2010) which reported the similar adsorption phenomenon.

Table 2: Isotherm constants and correlations for adsorption of color and COD onto GAC-CS

Isotherms	Constants		
Langmuir	q_m (mg/g)	K_L (mL/mg)	R^2
Color	93.46	0.9880	0.9900
COD	333.3	0.1030	0.9920
Freundlich	n	K_F (L/g)	R^2
Color	0.5900	1.660	0.9521
COD	0.6600	3.990	0.9537

4 CONCLUSIONS

The color and organic compound reduction of biogas effluent was investigated using commercial activated carbon (GAC-CS). The GAC-CS had high surface area of 1,048.43 m^2/g and the total pore volume of 0.4505 cc/g. The dose of GAC-CS required for color removal depended on the initial biogas effluent concentration. The adsorption efficiency increased with increasing GAC-CS dosage and was favored at an acidic pH. The adsorption of color and organic compounds on GAC-CS is well explained by Langmuir isotherm model.

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Screening Mesophilic and Thermophilic Consortia for Polylactic Acid-Bioplastic Degradation

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Abstract: Environmental concern over petroleum-based plastic waste could be mitigated by the use of bioplastics which are naturally biodegradable. Consequently, the use and production of biodegradable plastic especially polylactic acid (PLA)-bioplastic (one of the most popular bioplastics) have been increasing worldwide. For efficient PLA-bioplastic waste management, this research focused on PLA-degrading bacterial consortia screening in various conditions including mesophilic and thermophilic under aerobic and anaerobic environment. Eighteen samples were collected from various sources (hot spring, sanitary landfill, and microbial sludge) in Chiang Mai, Thailand. Thirteen isolates were obtained using basal medium emulsified with 0.1% of PLA as a growth medium with protease and/or lipase production capability. Therefore, the selected consortia showed the greatest ability to produce protease and/or lipase enzymes. Also, the consortia utilize lactic acid to support their growth. These results showed each consortium has a different main role to apply for PLA waste management. This study demonstrated on mesophilic and thermophilic consortia that degraded PLA at various conditions for bioplastics waste management.

Keywords: Bioplastics, Polylactic acid, Polylactic acid degrading consortia

1 INTRODUCTION

Petroleum-based plastics, which take significant time to degrade, cause a serious environmental pollution. Bioplastics which could be degraded naturally through biological process could be a promising alternative that can replace petroleum-based plastic use (Penkhrue et al., 2015; Urbanek et al., 2017; Bubpachat et al., 2018; Satti et al., 2019). Global bioplastics production capacity is expected to continuously increase from 2.1 million tons in 2018 to 2.6 million tons in 2023 (European Bioplastic, 2018). Polylactic acid (PLA)-bioplastic is the one of the most used biodegradable plastics produced from fermentation process of renewable resources. PLA is a thermoplastic with a glass transition temperature of 60°C and a melting temperature of 175°C (Leja and Lewandowicz, 2010). PLA has a wide range of physical and mechanical properties such as toughness, biodegradable, high modulus, tran-sparency, bio-absorbability, and non-toxicity (El-Meihy, 2016; European Bioplastic, 2018; Bubpachat el al., 2018). Consequently, PLA could be used in several applications such as agricultural films, biomedical devices, surgical-implant materials, packaging materials, and automotive industries (El-Meihy, 2016; Qi et al., 2017). The degradation of PLA depends on environmental conditions such as pH, humidity, temperature, and the presence of oxygen. Biodegradation of PLA relies on enzyme activities excreted from microorganisms such as actino-mycetes, bacteria, fungi, and yeast. The enzymes mostly act on the breakdown of ester bonds of PLA polymer into oligomers, dimers, and monomers (Penkhrue et al., 2015; Qi et al., 2017) and most of the PLA-degrading enzymes are in the protease family (Pranamuda and Tokiwa, 1999; Liang et al., 2016). Several PLA-degrading enzymes and micro-organisms include PLLA depolymerase and esterase from *Basillus smithii* PL21 (Sakai et al., 2001), proteinase K from *Tritirachium album* (Leja and Lewandowicz, 2010), protease and PLA-degrading enzymes from *S. pavanii* CH1 and *P. geniculate* WS3 (Bubpachat et al., 2018), and PLA polymerase from *Pseudomonas tamsuii* TKU015 (Liang et al., 2016). Although, there were many researches that studied on PLA-degrading bacteria, most of them focused on the use of pure culture (Qi et al., 2017; Bubpachat et al., 2018). However, Nair et al. (2016) reported that the consortia are more effective in PLA degradation than that obtained from the pure culture. And the bacterial consortia were helping to accelerated biodegradation of PLA (Pattanasuttichonlakul et al., 2018). Also, screening of bacterial consortia for PLA degradation would help for efficient PLA-bioplastic waste management as working condition would relatively close to the real environment. Moreover, the bacterial consortia that could work at relatively high temperature (higher than 58°C; a glass transition temperature of PLA) would help enhancing PLA degradation efficiency through both aerobic and anaerobic processes (Sakai et al., 2001; Apinya et al., 2015; Urbanek et al., 2017). Therefore, this study aimed to screen mesophilic and thermophilic bacterial consortia for PLA degradation under aerobic and anaerobic conditions for PLA-bioplastics waste management.

2 MATERIALS AND METHODS

2.1 Sample Collection

Eighteen samples were collected at various locations in Chiang Mai, Thailand. The samples were collected from soil and water from hot spring at Doisaket and Sankampang; soil, wastewater, and leachate from sanitary landfill site (Bantan sanitary landfill); and microbial sludge from channel anaerobic digester of animal manure and organic waste. The selected location was based on the location where expected consortia would be found such as thermophilic consortia would be expected from hot spring.

2.2 Mesophilic and Thermophilic Consortia Isolation

Basal medium (0.2% K_2HPO_4, 0.5% $MgSO_4 \cdot 7H_2O$, 0.1% KH_2PO_4, and 0.4% $(NH_4)_2SO_4$) emulsified with 0.1% PLA (3052D, NatureWorks LLC) were used for bacterial consortia isolation. The PLA resin was in a semi-crystal form with a specific gravity of 1.24 g/cm^3, peak melt temperature of 145-160°C, glass transition temperature of 55-60°C, and molecular weight (M_W) 228.2 kg/mol (Immonen et al., 2017). One gram (for soil sample) or twenty-five milliliters (for water, leachate, and microbial sludge samples) of raw samples were transferred into 125-mL Erlenmeyer flask and 125-mL glass vial for microbial screening in aerobic and

anaerobic conditions, respectively. The samples were added with basal medium containing 0.1% of PLA to maintain 50 mL of working volume and the samples were then incubated at 150 rpm and temperatures of 35°C (mesophilic condition) and 60°C (thermophilic condition) under aerobic and anaerobic conditions. To create anaerobic environment, all glass vials were sealed with rubber stoppers and flushed with nitrogen gas for three mins. The resulting bacterial culture grown on the medium was then subcultured into the fresh basal medium containing 0.1% of PLA. Bacterial subculture was done twice and the microbial cells were harvested by centrifugation at 7,500 rpm for 5 min. Cell pellets were collected and washed with phosphate buffer pH 7.0 and kept in 20% glycerol prior to be stored at -20°C until further used.

2.3 Bacterial Consortia Screening for Protease and/or Lipase Productions

All bacterial consortia were screened for their ability to produce protease and lipase enzymes using skim milk and tributyrin (TBA) agar plates, respectively (Carrazco-Palafox et al., 2018). Each consortium was cultured in basal broth with 0.1% yeast extract at 35°C or 60°C under aerobic or anaerobic conditions for 24 h. Ten microliters of culture were spotted in sterile disc (6 mm diameter) and the disc was then placed on agar plate. The plates were incubated under each consortia growth condition. Protease and lipase productions were indicated by the presence of clear zone around the colonies measured by a vernier caliper. The activity ratio was calculated followed by equation (1) (Ardihi et al., 2019). The consortium that showed protease and/or lipase production in each condition were selected for further experiment.

$$R = (X1-X2)/X2 \quad (1))$$

Where:
R = Activity ratio
X1 = Clear zone diameter (mm)
X2 = Colony diameter (mm)

2.4 Bacterial Consortia Screening for Lactic Acid Utilization

The consortia containing protease and/or lipase production in each growth condition were selected to test their ability for lactic acid utilization as a carbon source. Selected consortia were grown in basal broth with 1% yeast extract under each consortium growth condition for 24 h to prepare inoculum culture to test their ability to utilize lactic acid. A 10% of the prepared culture was inoculated into basal medium broth containing 10 g/L lactic acid (El-Meihy, 2016) then incubated under their specific growth conditions. After 5 days of incubation, bacterial growth was measured using spectrophotometer at 660 nm (OD_{660}). The control sample was performed using the basal medium without bacterial consortia inoculum under each of the growth conditions.

3 RESULTS AND DISCUSSION

3.1 Mesophilic and Thermophilic Consortia Isolation

A total of 13 bacterial consortia were isolated from various samples as showed in table 1. Under aerobic condition, there were three mesophilic and four thermophilic consortia. Whereas anaerobic condition yielded five mesophilic and one thermophilic consortia. A small number of the resulting consortia (13 isolates) was in close agreement with Pranamuda et al. (2001) and Bubpachat et al. (2018) who reported that PLA-degrading microorganisms were not widely distributed in environment when compared with microorganisms that can degrade other bioplastics.

3.2 Protease and Lipase Productions

All 13 isolated consortia were tested for their ability to produce protease and lipase enzymes as showed in table 2.

Under aerobic condition, there were 4 bacterial consortia (2 mesophiles and 2 thermophiles) out of 7 that showed ability to produce protease and/or lipase enzymes. It is interesting to note that mesophilic bacterial consortia yielded higher enzyme activity ratio with respect to the thermophilic bacteria consortia. Under mesophilic condition, EML1 isolate produced only protease enzyme with the highest activity ratio of 1.00; whereas, EMD1 isolate could

Table 1: Bacterial consortia from various sources and environmental conditions.

Sources of sample	Number of consortia (isolates)			
	Aerobic condition		Anaerobic condition	
	35°C	60°C	35°C	60°C
Hot spring #1 (D)	1	2	1	1
Hot spring #2 (S)	-	2	-	-
Landfill site (L)	2	-	-	-
Acclimatized PLA sludge (P)	-	-	2	-
Sludge #1 (M)	-	-	1	-
Sludge #2 (T)	-	-	1	-
Total	3	4	5	1

produce both protease and lipase enzymes under with lower protease activity ratio when compare with that of EML1. Like the thermophilic consortia, both ETS2 and ETD1 could produce protease, but only ETS2 had lipase activity.

Under anaerobic condition, there were 4 mesophilic bacterial consortia that could produce protease or lipase enzymes. None of the isolates contain both protease and lipase activities. Also, thermophilic anaerobic bacterial consortium showed no such enzymes activities. NMP1 showed the highest activity ratio of protease enzyme, followed by NMT1, and NMM1, respectively. While NMP2 showed lipase enzyme. There are many researchers reported that PLA were significantly degraded mainly by enzymes protease and lipase (Penkhrue et al., 2015; El-Meihy, 2016; Penkhrue et al., 2017; Qi et al., 2017). Protease catalyzes the hydrolysis of peptide bonds and ester bonds. Lipase cleaves PLA to low molecular weight and random copolymers. However, it is not necessary that both enzymes needed in the degradation process. Other PLA-degrading enzymes which can hydrolyze ester bonds namely esterase and enzymes which could depolymerize other components mixed in the PLA-bioplastic product could also act in this process (Liang et al., 2016; Bubpachat et al., 2018) Therefore, isolates that could grow on screening medium with PLA as carbon source showed no lipase/protease enzyme activity.

Table 2: The ability of mesophilic and thermophilic consortia for protease and lipase productions under aerobic and anaerobic conditions.

Conditions	Temperature (°C)	Consortia	Protease Ratio	Lipase Ratio
Aerobic	35	EMD1*	0.53	0.23
		EML1*	1.00	-
		EML2	-	-
	60	ETD1*	0.27	-
		ETD2	-	-
		ETS1	-	-
		ETS2*	0.29	0.24
Anaerobic	35	NMD1	-	-
		NMT1*	0.42	-
		NMM1*	0.33	-
		NMP1*	0.44	-
		NMP2*	-	0.20
	60	NTD1	-	-

(-): clear zone not detected (*): selected isolates used in the further experiment

The name code of consortia: (E) aerobic condition; (N) anaerobic condition; (M) mesophilic consortia; (T) thermophilic consortia; and the last alphabet indicating location where the consortia were collected

3.3 The Utilization Lactic Acid as a Carbon Source

The selected consortia were tested for their ability to utilize lactic acid. The results are summarized in table 3. Only EML1 was able to utilize lactic acid as a carbon source for their growth under mesophilic aerobic condition. Other isolates showed no prove to grow on medium containing lactic acid. It is because that the consortia only could depolymerize PLA polymer into oligomers and/or monomers but they have no such ability to use lactic acid monomers as a sole carbon. Some genus in actinomycetes, the dominant microorganisms for PLA degradation, has PLA-depolymerize enzymes with no potential to grow on medium containing lactic acid (Decorosi et al., 2019). It is important to point out that the complete natural PLA degradation process includes PLA depolymerization and lactic acid utilization resulted in carbon dioxide and water as the final products. However, both processes could be driven by different group of microorganisms depending on their growth condition. Aerobic PLA-degrading microorganism usually contains both mechanisms and thus easy for single-step PLA waste management. Konkit et al. (2012)

reported the microorganism biodegraded PLA film and utilized byproduct for their growth. Therefore, the resulting EML1 isolated from leachate, which could possibly have high concentration of lactic acid due to the organic substances hydrolysis in landfill process, under aerobic condition contained bacterial consortium rich in PLA-depolymerizing and lactic acid utilizing activities. On the other hand, anaerobic PLA-degrading microorganism inherently act on PLA-depolymerization process and the other step could be done by other group of microorganisms such as biogas producing bacteria (Wang et al., 2011; Bátori et al., 2018).

Table 3: The consortia growth in media containing lactic acid as a sole carbon.

Conditions	Temperature (°C)	Consortia	OD_{660}
Aerobic	35	EMD1	-
		EML1	1.486
	60	ETD1	-
		ETS2	-
Anaerobic	35	NMT1	-
		NMM1	-
		NMP1	-
		NMP2	-

4 CONCLUSIONS

This study isolated mesophilic and thermophilic bacterial consortia producing PLA-degrading enzyme (protease and lipase enzymes) under aerobic and anaerobic conditions. Thirteen isolates were derived under various growth conditions including, 3 isolates for mesophilic aerobic, 4 isolates for thermophilic aerobic, 5 isolates for mesophilic anaerobic, and 1 isolate for thermophilic anaerobic. The EML1 isolate could produce protease enzyme with ability to utilize lactic acid under mesophilic aerobic condition. Thus, this isolate has potential in single-step complete PLA waste management. Other isolates that could depolymerize the PLA polymer can potentially be applied in energy-related field with the aid of other microbial groups to depolymerized PLA waste with subsequent biogas production.

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The Design and Development of Smart Farm with Environmental Analysis

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Abstract: This research proposes the development of intelligent agriculture for growing vegetables in the community. Sensors were used to measure and store environmental data that affected the growth of plants within agricultural plots, such as soil moisture and weather sensors. The data obtained would be analyzed to compare with the suitable environment for growing of plants. The system also automatically controlled the distribution of water according to the needs of plants, making it easier to track and control the amount of resources used.

Keywords: Smart Agriculture, Environmental Analysis, Agricultural Water Management

1 INTRODUCTION

Agriculture is a manufacturing sector that is important to Thailand economy and uses a lot of labor in this sector. The agricultural sector produces food for both domestic consumption and export, as well as being a base for the industrial sector. Currently, farmers are facing not enough labor problems in the agricultural sector because new generation workers are less likely to be farmers. Climate change causes water shortage, drought, resulting in decreased quality of agricultural products. These problems affect both the environment and the reduced income of farmers.

This research proposed to develop smart agriculture for growing vegetables in the community together with technology to measure and collect environmental data that affected the growth of plants. The sensors included soil moisture and weather sensors such as light intensity, relative humidity, wind speed, and temperature to monitor and analyze the impact of the environment on the use of plant resources.

2 MATERIALS AND METHODS

2.1 Relationship Between Water and Soil Moisture

The soil consists of 4 parts which are soil (inorganic matter), biological (organic matter), water, and air. The soil suitable for cultivation must contain all four parts in the right quantities. Each area has an unequal proportion of soil composition. When receiving soil water, there would be water holding and drainage that is different for each type of soil.

This experiment was to find the relationship between the amount of water added and the soil moisture of the experimental area by mixing the soil with planting material at ratio 1:2. Therefore, in the experiment, 1 mm of water was poured to the soil at a time, starting from 0% soil moisture and measure the change of soil moisture from 0-100% (Prueger, 2005).

2.2 Water Consumption of Tomato

Water consumption of plants can be calculated with climate data or Reference crop evapotranspiration (ETo). (Ji, 2017). In this experiment, Penman Monteith method is used to calculate in Eq.1. ETo referred to the water consumption of the plants received, but it can be used to calculate potential crop evapotranspiration (ETc) in Eq.2. The crop coefficient (Kc) would change with the age of the tomatoes, as shown in Table 1 (Irrigation Water Management Division, 2011).

$$\mathrm{ETo} = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}U_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34U_2)} \quad (1)$$

$$\mathrm{ETc} = \mathrm{ETo} \times \mathrm{Kc} \quad (2)$$

Table 1: Crop coefficient of tomato (Kc).

Week	1	2	3	4	5
Kc	0.73	0.82	0.91	1.01	1.12
Week	6	7	8	9	10
Kc	1.21	1.3	1.36	1.41	1.41
Week	11	12	13	14	15
Kc	1.37	1.31	1.22	1.08	0.92

2.3 Environment Analysis System

To study the suitable environment of plants in this research, tomatoes were used for testing. Tomato was planted in the net house that the light can pass as shown in Fig. 1(a) and (b) (Kusmierek, 2012). Soil moisture sensors were installed in the tomato pots as shown in Fig. 1(c). Weather stations are installed at the greenhouse to measure the weather conditions, including temperature, humidity, light intensity and wind speed (Fig. 1(d)). Data from the soil and weather conditions sensors would be used to analyze for the amount of water necessary for the tomatoes (Cheema, 2013). The data were collected in the experiment between 1-31 December 2019 by measuring and collecting data every 1 minute. The collected data were averaged to analyze the daily water consumption of tomatoes.

(a)

(b)

(c)

(d)

Figure 1: Tomato planting house (a) outside net house, (b) inside net house, (c) soil sensor and (d) weather station

3 RESULTS

3.1 Soil Moisture Analysis

Figure 2 showed the relationship between watering and soil moisture experiment in different soil moisture levels. In the soil moisture range at 0-30%, it was found that the soil moisture level would not increase sharply when watering, due to the low moisture of the soil and most of the water was absorbed in the soil. In the moisture range of 30-90%, the soil moisture increases faster because the soil is more hygroscopic, so some water is not absorbed. Therefore, higher moisture can be measured. In the moisture range of 90-100%, the soil is characterized by being saturated with water and some water mixed with the soil until it is homogeneous, resulting in not much increasing moisture with watering. This experiment, from 0-100% moisture, uses 16 millimeters of water in total. From the experiment, the relationship of water to soil moisture can be used to evaluate and calculate the necessary amount of water to plant.

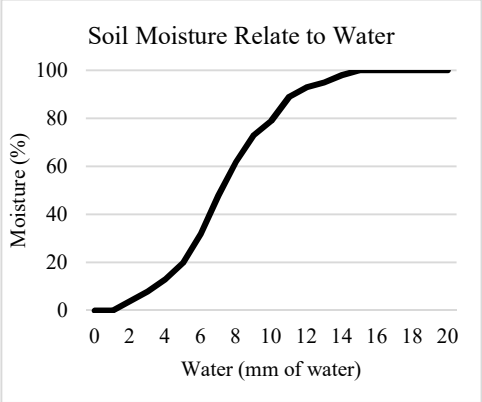

Figure 2: Relationship of water and soil moisture

3.2 Weather and Water Consumption Data

The analysis of the environment in the experimental field showed that as tomatoes grow older, more water is needed because the crop coefficient (Kc) would increase each week according to the Eq.2. Solar radiation, temperature, and relative humidity also affected plant water use. Data collection from soil and weather condition sensor at the experimental field between December 1 - 31, 2019 showed average of weather conditions and water consumption of

tomato (Fig.3). Average solar radiation was 12.03MJ/m^2-day, average temperature was 22.94 ° C, average wind speed was 2 m/sec and average of relative humidity was 58.55%. From the Fig. 3 between 29 - 31 December 2019, there was rain in the experimental area. It resulted in high relative humidity, low solar radiation and low temperature, resulting in reduced evaporation of water and decreased water consumption of tomatoes. Conversely, as the relative humidity decrease, temperature and solar radiation increase, the ETo in the soil would also increase.

Mean hourly values of tomatoes reference in sunny and rainy day are shown in Figure. 4. The mean hourly values of tomato was shown a roughly parabolic trend pattern during the sunny day. On the rainy days, mean hourly values of tomatoes will change according to the weather, corresponding to the changes in diurnal solar radiation and rainfall.

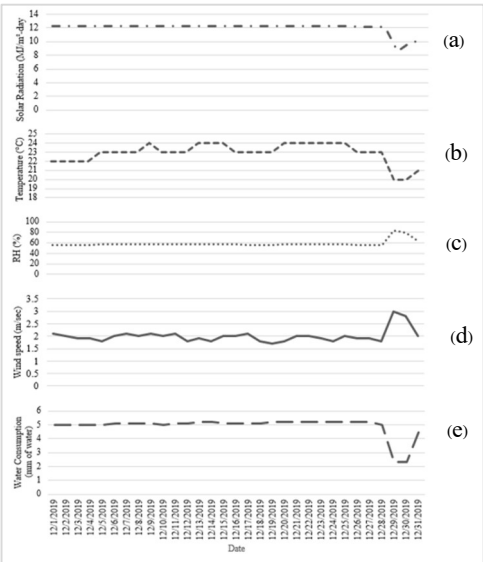

Figure 3: Weather and water consumption data (a) solar radiation, (b) temperature, (c) relative humidity, (d) wind speed and (e) water consumption

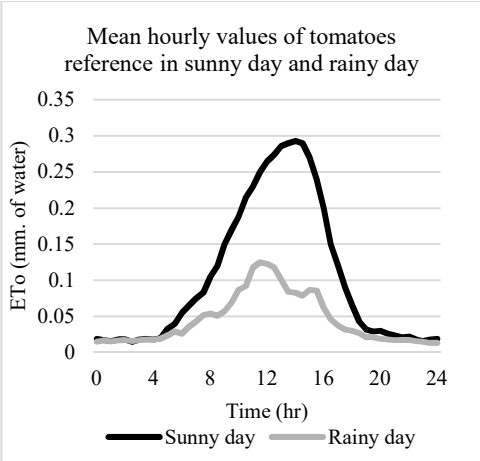

Figure 4: Mean hourly values of tomatoes of reference crop evapotranspiration in sunny day and rainy day

4 CONCLUSIONS

In this research, we designed and developed intelligent agriculture systems using local environmental data such as soil and weather conditions to analyze and control the amount of watering that is appropriate to meet the needs of tomatoes. The experiment was collected from 1 - 31 December 2019. The system has installed in the net house and using tomatoes as experimental plants. This study found that weather conditions greatly affect water use behavior of plants, especially solar radiation, temperature and relative humidity. This system can be adapted for other plants as well. The crop coefficient (Kc) can be adjusted according to the type of plant.

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Sustaining the Humanities – Syntax of the East The context of Kuala Lumpur, Malaysia

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Abstract: The paper discusses the socio-spatial sustainability of the city of Kuala Lumpur (KL), Malaysia, as a case for understanding the logics of Space Syntax in the context of the East. The Sustainable Design Goal 11 proposes ideas to make cities and human settlements inclusive, safe, resilient and sustainable. The paper approaches this goal through the notion of integrated devevelopment of landuse to an effective network of connectivity. The research employs Space Syntax software as a tool for urban analysis and Sustainable Street Networks developed by Congress of New Urbanism as a tool to identity opportunity to improve the connectivity and public realm. Firstly, the study is undertaken to understand the spatial logic of the city through Space Syntax to enlighten on the hierarchy of connectivity of the urban configuration, the streets. Secondly the research is carried out to analyse the areas of high integration values in the Space Syntax Maps to the land use of the city in order to find social synergy. Lastly the conclusions are drawn on how the Space Syntax maps could be further useful to develop the key characteristics towards the SDG11. The investigated setting is unique and the first attempt in generating Space Syntax map to the city of Kuala Lumpur and the findings therefore offer a new set of knowledge-base to the city planners, urban designers and architects.

Keywords: Sustainability, Space Syntax, connectivity, public realm, street network configuration, Kuala Lumpur

1 INTRODUCTION

The city of Kuala Lumpur faces rapid urbanization and is growing into one of the significant mega-cities of the South East Asia. Being a highly competitive city in the global market, the city and its conurbations face tremendous change in its structure and land use. Kuala Lumpur is a city that exhibits a contrasting co-exhistance of the village and the city. The city's landscape is shaped by multiple urban enclaves of colonial, malay, chinese and indian settlements coexisting with the contemporary developments. The city therefore, deserves sustained attention from the research and development sector. It is time that the locational aspects of such historic enclaves and contemporary developments need to be understood interms of sustainability both spatially and socially.

The World Urban Forum 9 (WUF9) launched the Kuala Lumpur Declaration 2030, which was inviting all efforts, means and resources available towards the concept of cities for all, ensuring that all inhabitants are able to inhabit and produce just, safe, healthy, accessible, affordable, resilient and sustainable cities and human settlements to foster prosperity and quality of life for all. The Declaration also announce the strategy to adopt accessibility and universal design as core principles for implementing the New Urban Agenda through inclusive, accessible and participatory processes and consultations. Thus accessibility and public spaces have gained prime focus in the Declaration.

Urbanice Malaysia, a Centre of Excellence under the Ministry of Housing and Local Government,, envisions to achieve Urban Village ideas to Kuala Lumpur, in which pedestrianization becomes the focus. Mobility is the key. Public realm is challenged due to the notion of streets being changed to the notion of roads. More importance has been given to vehicles than pedestrians. Space Syntax, as a science and logarithm of the system of networks, is powerful tool to understand whether the connectivity in a city exhibits legibility and hierarchy.

The Sustainable Design Goal 11 (SDG) proposes ideas to make cities and human settlements inclusive, safe, resilient and sustainable. The paper approaches this goal through land use of the local communities integrated to an effective network of connectivity. Effective placemaking demands sensitivity to and cognizance of, power dynamics in and across *urban space* and its production (Carmona et.at, 2010). This reinforces the importance of power dynamics on active and vital public spaces in the city. On these lines of thought in order to offer a scientific and systematic approach, the research employs Space Syntax (Hiller, et. al., UCL) software as a tool for urban analysis. The Congress for the New Urbanism (2012) suggests six key characteristics, to make a humane design possible, as a toolkit for urban design and successful place making in cities. The movement pattern is given primary importance here to offer connectivity to urban form and function. It is asserted that the street network provides the setting for commercial and social interaction, and that construction, operation, and maintenance of the street network is primarily to serve people and society. Although there are many publications on testing Space Syntax to suit the principles of New Urbanism, a collaborative approach of findings of Space Syntax to the Sustainable Street Networks principles, still remains new in the field.

Therefore it is intended in this paper to a) keep street (as the 'structure') and urban space (as the 'place') at the heart of discussion and analysis and b) outline collaboratively how the syntactic findings from the city of Kuala Lumpur could be best for the key characteristics suggested by the Congress of New Urbanism towards a better connectivity.

2 METHODOLOGY

The paper aims to illustrate opportunities to develop the city towards effective public realm and placemaking. In order to achieve this it is intented to use the findings from Space Syntax analysis to be conducive to the key characteristics suggested in the Sustainable Street Network by the Congress of New Urbanism (2012). In this discussion the spatial aspect or 'the structure' is discussed through street connectivity scientifically obtained from Space Syntax (Hillier et.al.) and the social aspect or 'the place' is discussed through the functional dimension of the city. Whilst the discussion on structure follows the syntactic analysis, those on place follow the data from land use map of the city.

The questions this paper will explore are:

a) How can space syntax spatial models offer understanding on urban structure?

b) How can the existing land use on activity and movement patterns of Kuala Lumpur correlate with Space Syntax findings?

c) What are the power characteristics and possible opportunities to develop the city towards

Sustainable Street Networks in a form easily understood by architects, planners and clients?

The methodology is the procedure of case study and the method employed is Space Syntax. Firstly, the research is undertaken to understand the spatial logic of the city through Space Syntax software to enlighten on the hierarchy of connectivity of the urban configuration, the streets. Secondly the research is carried out to compare the areas of high integration values in the Space Syntax Maps to the land use map of the city in order to find social synergy or the functional usage. In terms of activity aspects of a city, many literatures in urban design state and justify that the commercial streets of a city offer to lively nodes (Hillier, 1999), create places of safety and natural surveillance (Jane Jacobs, 1961) and promote places for social interaction (Oldenburg, 1999). There are many studies that showed that spaces with more integrated configuration (from the point of view of Space Syntax) tend to be more sought after and, therefore, with greater flow of people and therefore commercial landuse (Hiller et.al., 1999 ; Juliana & Augusto, 2017). Following the literature on Space Syntax, the paper will find synergic relationship between the structural logic (Space Syntax) and the functional usage (mainly the commercial land use).

Thus the contributions of the paper are: a) the structure for a city as mainly seen through the streets and the connectivity of them. It should be noted that the data generated in the research, Space Syntax Map, is itself a new, original and primary source developed by the research team and b) the discussion on application of Space Syntax findings to urban design through the Sustainable Street Network characteristics, suggested in the Sustainable Street Network by the Congress of New Urbanism (2012).

3 SYNTAX AND THE CITY

This part of the study is to focus on the spatial form analysis (Space Syntax, 2018) using integration values produced by the software, The research is first attempt in generating such a map to the city of Kuala Lumpur and therefore offers a new knowledge base to the city planners, ubran designers and architects.

Space Syntax method consists of calculating configurative spatial relationships in built environments. It addresses the relationship between physical elements of a city and its social activity pattern of utilization (Yamu and Voigt 2011). It is a set of techniques for the representation, quantification and interpretation of spatial configuration in buildings and settlements (Hillier et al., 1987: 363). The cornerstone of the space syntax methodology is a simple mathematical/graph theory procedure, intended to analyse plans to arrive at cultural norms behind their morphology. The theory of 'space syntax' is that it is primarily, though not only, through spatial configuration that social relations and processes express themselves in space (Hillier et.al, 1987: 363). Space Syntax software analysis determines the relative connectivity value of each line (representing the street) with respect to all other lines of the system and creates an analysed map which shows the relative 'integration' of each street in the city. Urban spatial form analysis is able to give these integration values at both a global level (integration of each street to all other streets of the city) level and a local level (integration of each street to the next two or three streets).

Space Syntax studies were undertaken both in the city and local contexts investigations. From the Figures 1 and 2, it can be interpreted on the streets of high (red in color), medium (yellow and green in color) and low (blue in color) integration values. The street structure of city of Kuala Lumpur consists of the larger core with patches of deformed grids, and a few very long and radial roads which connect this core to the periphery. The city mostly has non-orthogonal grids, with a broken line structure, since every road does not cross over the highways, canals, rivers and railway lines of the city.

Table 1 below shows that compared to other parts of the world, Eastern cities seemingly, have lower syntactic values. A Space Syntax study on Indian cities (Srirangam & Forsyth, 2011) showed that the city has lower connectivity and integration values, which are attributed to its non-orthogonal structure. Likewise, the City of Kuala Lumpur has also lower connectivity and integration than the other cities, which is due to the non-orthogonal grids or the radial roads, multiple historic centres and a broken line structure. Another study on Jeddah (Acharya et.al, 2017) found that the city was full of multi-centred nuclei offering to hetrogeneous structure.

These findings offer an interesting comparison of the Eastern and Western cities; the Eastern cities grow from multi-centres, usually historic, that are connected by contemporary highways which inturn disintegrate the historic enclaves as urban islands. This is opposed to organic cities of the West, where a city grows from one core or the centre and naturally disintegrate or move as it grows bigger. It was

found that British cities tended to disintegrate in terms of global integration when they grow bigger (Hillier, 1996). Eastern cities display hetrogeneous, multi-centred, lowered connectivity as opposed to homogeneous, single-core and higher connectivity of Western cities.

The lower integration of streets is caused mainly by the highways, running through city and dividing the settlements within the city. It is therefore important to note:

a) Major roads and rail infrastructure disconnect links between adjacent areas,

b) These dividing-highways are the reasons for the poor pedestrian and local connectivity with in the city and therefore affect the pedestrian quality of the city. This leaves the city the archipelago effect, i.e., islands in the city causing cities within the city and

c) The historic enclaves of the city, mostly are of deformed grid structure and therefore have higher syntactic values and connectivity. Such patterns confirm the value of the morphological growth of the city through the history.

Table 1. International comparison of the syntactic values

City/Country	Number of cases	Connectivity	Local	Global Rn
USA	12	5.835	2.956	1.610
UK	13	3.713	2.148	0.720
Middle East	18	2.975	1.619	0.650
India	2	3.104	1.674	0.633
Kuala Lumpur	1	2.761	1.501	0.380

Source: Srirangam S & Forsyth L (2011) and the authors

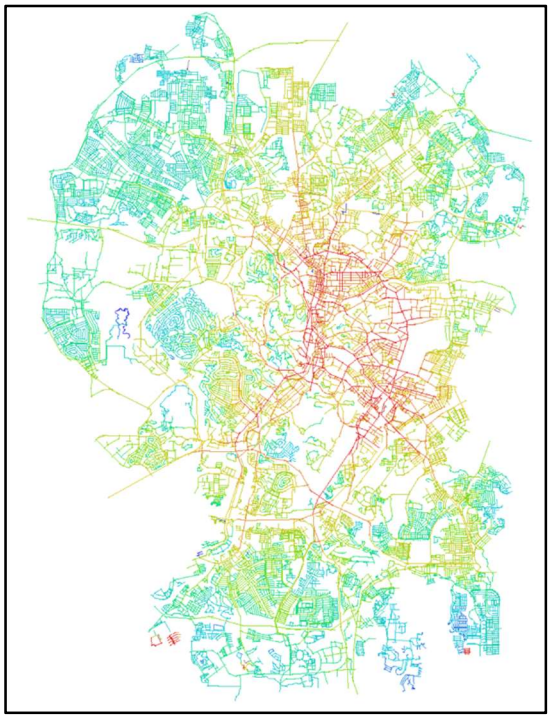


Figure 1: Kuala Lumpur, Space Syntax Map: Global Integration

Source: the authors

Figure 2: Kuala Lumpur, Space Syntax Map: Local Integration

Source: the authors

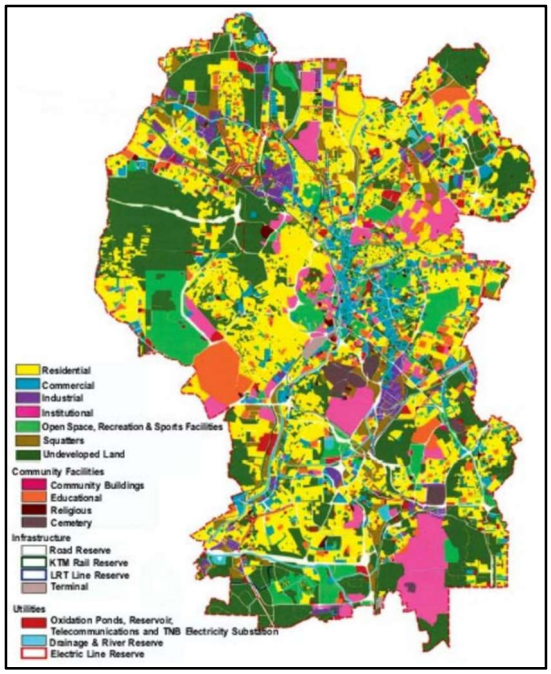


Figure 3: Kuala Lumpur, Land use Map

Source: DBKL Website

4 SYNTAX CONFIGURATION IN CORRELATION TO LANDUSE

This is the second stage of investigation where in the spatial logics are tested for the functional dimensions of the city. While we compare the structural logic of the city generated by the Syntactic maps to the land use diagrams of the city, it is interesting to find the following significant patterns with the contemporary commercial hubs and the traditional community enclaves in the City, as mentioned below:

a) As in any other city, the commercial zone mostly follows the streets with highest integration. However it is very important to note that the once the global syntactic integration lowers down, the local syntactic integration values mostly have significant impact over the commercial land use.

b) The historic cores or the city center area of Petaling Street, Kampung Baru and Little India form an array of sequential high connectivity pattern, globally as well as locally, and mostly exhibit the qualities of retail development.

c) Whilst the residential land use mostly occupies the zones of moderate global connectivity, the institutional land use is plugged right in the central zones. The industrial zones are scattered outside the centre.

While the commercial land use is seen as 'live centres' (Hillier, 1999) in a city, the commercial manifestations in KL fall into two categories, namely, a) the traditional commercial streets such as Petaling Street and Bukit Bintang and b) the contemporary shopping complexes such as Times Square and Pavilion. Both of these categories occupy the streets of highest connectivity (red in color). The zonal articulation of residential and open spaces occupies the streets of next hierarchy of connectivity (green in color). We can conclude that at the city scale, there is evidence of the socio-spatial synergy that when space in well integrated with the rest of city, it acts as an attractor for intensified commercial activities. While the concentration of economic activities or the 'work' functions of the city happen at the streets of high syntactic values, the distribution of live and play take the streets of medium and low syntactic values. There is an evidence of mono functional articulation of work or economic activity on the streets high syntactic values, rather than having a diversity of functions.

It is interesting to find that the city's structural logic has significant patterns with commercial developments that could take the form of either the traditional shopping streets or the contemporary shopping malls. On the contrary it's important to find patterns in the historic places, such as Kampung Baru, Little India and Petaling Street. It is important to find and note that the cultural quarters of the historic zones of KL have their centric streets well integrated (high integration values) to the rest of the city structure. Kampung Baru, Petaling Street and Little India all exhibit same quality of permeability or connectivity to the city. These streets have high integration values both locally and globally and therefore have proven to be more successful as spatial attractors with a land use of retail development. The walkability to these streets and the choices of diverse activities are the keys for creating successful urban streets to keep the city lively. From the social, visual and temporal dimensions of the city these streets are strengths of well-being in the city. The functional or place making aspects on these streets could be made more diverse and adaptable in order 'to create a street network that supports communities and places.

It is beautiful for Kuala Lumpur that the historic cores form an array of sequential high connectivity pattern and mostly exhibit the qualities of mix use development. Whilst the residential land use occupies the zones of poor and moderate connectivity, the institutional land

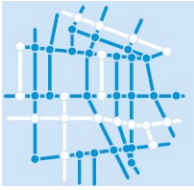
use is plugged right in the central zones. The industrial zones are scattered outside the centre.

5 DISCUSSION ON SDG GOAL 11

The Sustainable Design Goal 11 (SDG) proposes ideas to make cities and human settlements inclusive, safe, resilient and sustainable. On these lines of thought, the research employs the six key characteristics of the Sustainable Street Networks (SSN) suggested by the Congress for the New Urbanism (2012). Although there are more research works on the SSN, collaborative approach of findings of Space Syntax to the Sustainable Street Networks still remain new in the field. Below is the discussion on identifying opportunities, by mapping the space syntax findings to the key characteristics from the 'Sustainable Street Network'.

5.1 Key Characteristic 1

A web of streets and travel modes that maximize connectivity



SSN suggests that well-connected street networks improve mobility by allowing people to travel more directly. This makes destinations more accessible by walking, and enlarges the capture area surrounding transit stations.

In the context of Kuala Lumpur, the findings imply that the high integration values in global and local space syntax maps suggest that these streets have high connectivity to the city and to the local historic and business enclaves. Secondly the continuity of pedestrian connectivity is largely missing due to the functional articulation of open spaces on those streets. Both of these findings prompts the need a) to become well connected through the choices of transportation modes following the hierarchy of connectivity and b) to revitalize the existing open spaces on the streets of high syntactic values, in order to offer continuity of public realm.

5.2 Key Characteristic 2

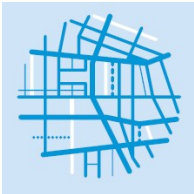
Desirable places where multiple networks overlap

There are multiple mode-specific networks and in some places they overlap. For example, pedestrian, bike, transit, and car networks may overlap on the street. In other places they may be separate, on trails or rails. The sustainable street network coordinates these connections and creates a quality environment where they overlap.

In the context of Kuala Lumpur, the findings imply that these streets evidence high connectivity and therefore successful in attracting more pedestrian population on street. This prompts the opportunity a) to establish complex options of route types following the hierarchy of connectivity, such as the streets of high syntactic values are to be accessible by most of the transportation modes and b) to focus more on public transportation to offer TODs with in 400m of walking distance from those highly integrated streets.

5.3 Key Characteristic 3

Inherently complex

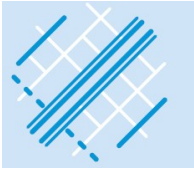


SSN features a rich array of street and route types—rather than just the same "flat" design used many times over. The amount and variety of streets determine a community's character, and whether it functions as a coherent whole or as disconnected islands separated by a few big streets.

In the context of Kuala Lumpur, the findings imply that the major roads have disconnected links between adjacent areas offering poor syntactic values. This prompts the need to increase the pedestrian connectivity by introducing boulevards, alleys and sky bridges to the adjacent areas.

5.4 Key Characteristic 4

Major streets designed and spaced properly



In a sustainable street network, major streets are the "Great Streets" of their cities and towns. These streets, generally classified as arterials and collector streets, are multimodal and designed to integrate with adjacent land uses.

The findings from this paper suggests that the major streets are of high integration values which mostly appear the heart of the historic enclaves. It is suggested a) to allow multiple types following the hierarchy of connectivity found in the global syntactic maps and b) to make the globally well integrated streets as public transport and vehicular roads and to make the locally well integrated streets as pedestrian connectors integrated to the public transportation routes.

5.5 Key Characteristic 5

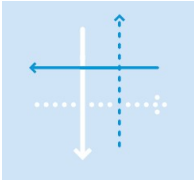
All streets safe and walkable

All streets are safe and walkable in a sustainable street network, no matter how many vehicles they accommodate, or how continuous they are across sections of a town, city, or region. This is both a safety and a public health issue.

In the context of KL, the articulation open spaces adjacent to the streets mostly offer to discontinuity of public realm for the pedestrians. It is important a) to improve the streets with high syntactic values for pedestrian safety. The hierarchy of connectivity in the local syntactic map is vital here and b) that the interface between architecture and urbanism could help to reinforce safety. The interstitial spaces and permeability of buildings, could offer to pedestrian comfort and therefore to public realm.

5.6 Key Characteristic 6

Wide variety of street types, each with a role in the network



The sustainable street network consists of all types of streets that accommodate many different travel modes. Some streets are designed to serve traffic in all forms. Others are designed to be quiet with only the occasional vehicle. Some span across a city, while others are less continuous to control traffic speed and volume.

In the context of KL, such variety is largely great but needs clarity in roles, almost a mix of most of the travel modes. Suggestion could be that the highly integrated streets in global syntax are potential to serve to connect across the city, whilst the locally well integrated streets could be kept for pedestrian.

6 CONCLUSION

It has been evidenced in the paper that the Syntax of the East, the case of Kuala Lumpur, is unique where the impacts of the new highways have been high and mainly reflected on the city's structure of street networks. Such impacts cause a tension in the city's structural configuration and therefore creating island effects in the historic enclaves. It can be noticed that the history and morphology still strive to continue the functionality in the contemporary scenario purely as manifestations of ethnicity, business and typologies. Such findings accelerate innovation on community driven spatial interventions and urban regeneration projects.

To answer to the initial research question of finding whether the city of Kuala Lumpur socially sustainable, whilst the social sustainability is defined as the synergy between spatial and social aspects of the city, it could be concluded that there is a synergy of structure and place in terms of land use distribution. However there is more opportunity for developing synergy at the local scale, where the urban open space becomes vital. The contemporary trend of creating new forms and functions without actually scientifically resolving the connectivity or movement pattern in the city, could further threaten the synergy

In addition, public spaces can be involved in urban revitalization projects. In line with this the next task in this syntactic research cluster would have to be on synthesis the changing roles of public spaces, the area better known as open space that can be used in a meaningful way to the urban public. Aspects of behavioral settings could be analyzed for the typologies manifested by Space Syntax through contextual relevance on culture and climate.

Overall, this paper a) exemplifies that it is important to prioritize the connectivity or the movement pattern in the city of KL through the Space Syntax Maps, before new programs or forms being proposed, b) explores the possibility of space syntactic findings to offer to the six characteristics of Sustainable Street Networks, c) stresses the importance to create continuity of public domain by revitalizing open spaces in the historic enclaves whilst care to be taken in terms of defining the open spaces in its form and functional aspects.

There is an opportunity on urban design recommendations to empower the city as a responsive environment through: a) establishing public realm following the integration values generated by the Space Syntax Global and Local Maps and b) underpinning humane design following the characteristics of Sustainable Street Networks in order to achieve walkability, public realm and better connectivity.

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Development of Sustainable Urban Drainage System Using Stormwater Management Model (SWMM)

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Abstract: In these days, most of the urban areas are faced with the urban flood in rainy season or in unpleasant condition of weathers. According to the raise of civilization, the amount of impervious surfaces increased all around the city. That's the reason why the stormwater cannot absorb into soil and are passing through the surfaces and get into nearest stormwater drainages. Sustainable urban drainages systems (SUDS) can be used for all types of development to provide a natural approach to drainage management. SUDS prevents urban water pollution and flooding. SUDS also creates green and habitat for wildlife in towns and cities. The study area of this study is flooded by the urban flood in the rain season of every year. This study is developing the drainage system in study area on the existing drainage system with the simulation of different drainage sizes in different scenarios by using the StormWater Management Model (SWMM). The simulation process required designing in different scenarios until the best solution was obtained. The study have three scenarios which are the process of simulation with existing channel sizes, same standard sizes for all channels and best hydraulic system for all channels. And then, the optimized one is chosen as the proper design drainage of the study area. To get a sustainable design, each channel will be updated with sustainable urban drainage system (SUDS). Among the many types of SUDS, Green roofs system is suitable for the study because of there have 75 % of roofing area in the study. There have two types of green roofs; extensive type and intensive type. Extensive green roof is used in the study. By using this, runoff coefficient is changed and the 35% ofdischarge of the study area is decreased.

Keywords: Sustainable Urban Drainage System(SUDS), Stormwater Management Model(SWMM), urban flood, green roof.

1 INTRODUCTION

According to the rise of civilization, the amount of water permeation in cities is lost every day. As the impermeable surface increases, the two are inversely proportional, reducing permeation and increasing surface runoff. Due to the growing population, water usage is increasing, urban drainage carries more water than initially, domestic water from homes is also rising, and most of them are plugged with waste. There are two types of water that require drainage, called stormwater and rainwater. These two types of water are controlled by an urban drainage system to mitigate the problem of urban floods that affect humans and the environment. Because of the rise of population, poor drainage systems, and heavy rains, most South-East Asian countries are facing urban floods.

1.1 Aim and Objective

The aim of this study is to develop a proper drainage network of study area by using SWMM and renovate as the proper drainage network design with the sustainable urban drainage system to be effective for the environment.

1.2 Study Area

The study area is Botahtaung Township,in the southern part of Yangon, Myanmar. The coordinate point is 16°46′3″N 96°9′5″E. The total area of the study area is 2.4 km^2 and consists of 10 wards. The town is known for its Botahtaung Pagoda, one of Yangon's famous pagodas. Botahtaung Township shares the northern and eastern borders with Pazundaung Township and Pazundaund Creek, in the Mingala Taungnyunt township, in the south Seikkan Township and Yangon River, and in the west Kyauktada Township. Figure 1 shows map of Botahtaung Township.

Figure 1: Botahtaung Township

1.2.1 Problem statement

The study area is located in downtown Yangon, Myanmar, called Botahtaung Township, where floods occur during the rainy season every year. Every year, during the rainy season, floods flooded the area with the town. Flood rates in this township area have increased year by year. The study area is located in downtown and a rise in the proportion of residential buildings this century has led to a drain overflow. And the other is torrential rain. It was also one of the reasons for the flooding of the city. Blocked drainage was also part of the reason making flood. The impervious side of the town has also increased with urbanization. Due to its surface type, the rate of permeability was declined. Several problems have arisen when floods have occurred in the study area. Roads were covered with water, transportation in the study area was facing difficulties, and people could not go to work and anywhere and also polluted the environment with mud and some trash. Some of the water goes into the basement or the ground floor of the building.

2 METHODOLOGY

In the methodology, there have been described about Stormwater Management Model, sustainable urban drainage system that concerns with the study, and the data collection of the study.

2.1 Stormwater management model's (SWMM) overview

The United States Environmental Protection Agency (EPA) Stormwater Management Model (SWMM) is a dynamic rainfall-runoff-routing simulation model used primarily for single event or long-term simulations of urban runoff and water quality. The SWMM spill works on a group of catchments that collect rainfall and generate spill loads and pollutant loads. The spill through pipe systems, channels, storage or processing equipment, pumps, and regulators are transported by the routed portion of the SWMM. SWMM tracks the volume and quality of wastewater produced in each sub-catchment, as well as the flow, depth and quality in each pipe and channel being simulated, in multiple time steps. (Miguez and de Magalhaes, 2010)

SWMM is widely used for planning, analysis and design of urban runoff, drainage combinations, sewer sanitation and other

drainage systems. SWMM provides a complex environment for compiling input data for the study area, performing hydrology, simulating water quality and hydraulics, and observing results in various formats. SWMM also includes color-coded drainage area and transport system maps, profile plots and analytical frequency analysis, time series tables and graphs. (Rossman, 2010)

Simulation of the design and size of drainage system components for flood control, additional design for detention device size and flood control and water protection, assessment of the impact of inflow and seepage on sanitary sewer overflow, control to minimize strategy design assessment for minimizing combined sewer overflows, flood plain mapping of natural channel systems, creating non-point source pollutant loadings for waste load allocation studies, evaluating the effectiveness of BMPs for reducing wet weather pollutant loadings are included as the typical application of SWMM.

2.2 Sustainable urban drainage system (SUDS)

Sustainable urban drainage systems (SUDS) provide a natural approach to drainage management. Replacing vegetation and permeable surfaces with concrete, pavement, and roof structures reduces the amount of surface water absorbed by the surface and is sent to surface water drainage. Sustainable systems, rather than flushing surface water into watercourses through a network of pipes, slow and control water, allowing natural processes to decompose and release pollutants in a more controlled manner. This will reduce the impact of new and existing building developments on surface water drainage, thus minimizing the potential for flash floods in extreme weather conditions. (Pinner, n.d.)

SUDS techniques include Green roofs (covered with vegetation), permeable surfaces, Ponds, Swales, Detention basins, Permeable paving, Wetlands and Filter drains.

SUDS installations prevent water pollution, reduce the risk of runoff and flooding on slowdown surfaces, reduce the risk of sewer flooding during heavy rains, recharge groundwater in drought-prone areas, and for wildlife in urban areas It can provide a habitat for wildlife and create green spaces in urban areas. (Pinner, n.d.)

2.3 Data collection

First, it was necessary to obtain the required data from the Yangon City Development Committee (YCDC), the administrative agency of Yangon. The flow direction and drainage network of the study area are obtained by YCDC's data. The drainage conditions in the study area had to be obtained because it was the data needed to simulate the flood. In the simulation of stormwater network design, data on the number of drains in urban areas was also needed to be easier in design simulation of storm water network

The location of the drainage network in the study area was one of the necessary data that could help set up the SWMM drainage network. The amount outlet and the location of the drains, the depth and width of the existing drainage, and the percentage of slopes are also essential data for the study. Satellite images should be used to study catchment topography, drainage elevation points, pipeline data, junction points, and conduits. Urban drainage parameters and other data that cannot be measured by maps or Google Earth are measured by site surveys. Drainage area, catchment width, catchment slope and land use are considered land cover areas.

3 RESULT DISCUSSION

In the model description, the characteristics of each subcatchments, junctions and other parameters of the model are presented by the respective tables.

3.1 Input data

The value of roughness factor for impervious area and pervious area are the same for every subcatchment. Concrete is used as the impervious layer for every subcatchment and tree is used as pervious layer. The value of these two roughness factor are 0.012 and 0.15 respectively.Characteristics of subcatchments of the Botahtaung Township are described in table 1.

Table 1: Characteristics of each subcatchment of the Botahtaung Township.

Subcatchment	Area of subcatchment (ac)	Width (ft)	Percentage of slope (%)	Percentage of impervious area (%)
S1	6.0	693	1.016	50
S2	15.5	790	0.221	60
S3	16.2	775	0.116	85
S4	17.1	840	0.776	70
S5	17.1	823	0.854	90
S6	17.3	830	1.287	65
S7	17.0	835	0.942	93
S8	17.0	843	0.114	95
S9	16.7	832	0.117	75
S10	18.0	836	0.472	50
S11	17.5	827	0.976	50
S12	17.2	828	2.169	95
S13	28.2	813	1.149	60
S14	13.1	639	0.308	80
S15	13.2	630	0.155	65
S16	13.3	625	0.457	70
S17	59.6	1691	0.117	55
S18	26.1	1040	0.502	50

After entered the conduit input data, there is need a time series to edit it. The time series is named TS1 and its graph is shown in the figure. Then a rain gauge turn arrives to fill the required data.

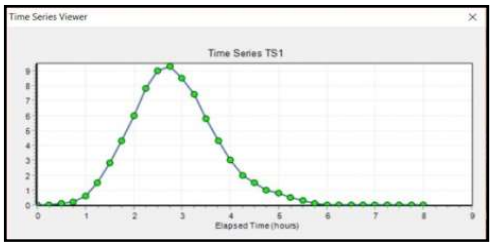

Figure 3.1: Time series graph

3.2 SWMM simulation

Using the input data described above have several consequences. Then, the water elevation profile that is the result of the simulation is checked. After reviewing the results, there are several changes in junction, elevation, and channel size in various simulations. In this different simulation, it is necessary to propose a drainage system suitable for the study area.

Botahtaung Township is about 589 acres and consists of 10 wards. In order to design stormwater drainage, it is necessary to divide a small subcatchments in the study area. There are many properties needed to get into the subcatchment on the map in SWMM. Figure 3.2 show subcatchments of the study area.

First, the study is divided into 18 subcatchments in the study area according to the elevation and determine the existing drainage network will carry the drainage or not. The details of the drainage channel size, junction height, and other parameters were confirmed. Since most of the impervious surface of study area is concrete, concrete is used as the roughness coefficient of the impervious area. In addition, the coefficient of tree is used as the coefficient of the pervious area. Modified Green AMPT is used as the infiltration method and the Kinematic Wave is used as the flow routing method.

There are various junction points in the study area, and the discharges from the sub-catchments flow into the relevant junction. All junctions are linked to the relevant conduit. After setting up the sub catchment and junction, the conduits are designed. All conduits are shaped with rectangular open channels and designed with concrete. This is why all conduits have a roughness coefficient of 0.015. The outfall is also linked to several junctions. There are eight outfalls in the study area and each has a different elevation.

After reviewing the above parameters, a suitable drainage network for the study area was designed. In this study, three scenarios needed to be prepared to obtain a tailored drainage design for the study area built by the Storm Water Management Model (SWMM). Different input data was inserted for each scenario. Also, the design of the drainage, especially the size, was not the same for each scenario. If the size of the drainage was different in each scenario, the profile of each water level was not the same.

The first scenario had an existing channel size for running the simulation, and a constant drainage size was used as the drainage design for scenario 2. In Scenario 3, there were different drainage sizes depending on elevation and discharge from respective subcatchments.

3.3 Scenario 1: Simulation with the existing network by using SWMM

In this scenario, C1 to C20, there are 20 conduits. Each conduit has its own size and shape, and Table 4 shows how it gets longer. The study area has 12 water level profiles. There are two water level profiles with backflow upstream. In the first, there was only backflow upstream, as the existing size of conduit is not enough to carry rainwater discharge. Another flow profile consisted of three conduits and the water flow here did not flow in steps. According to the appropriate conditions of the water profile, the water must flow from upstream to downstream by passing through the conduits on a conduit-by-conduit basis.

Figure 3.2: Subcatchments and designed junctions, conduits and outlets of the study area

However, in this flow profile, the downstream conduit overflowed, while the central conduit had empty space for drainage. Figure 3.2 shows the locations of subcatchments, junctions, conduits, and outfalls. Therefore, it is desirable that all conduit conditions of the same size have been tried to improve the drainage network in the study area of Scenario 2.

Table 4: The results of scenario 1

Conduit	Inlet node	Outlet node	Elevation	Existing Size		
				Depth(ft)	Width(ft)	Length(ft)
C1	J1	Out1	40	1.5	C1	J1
C2	J2	J1	47	1.02	C2	J2
C3	J3	J1	47	1.3	C3	J3
C4	J5	J4	41	1.4	C4	J5
C5	J6	J4	41	2.7	C5	J6
C6	J4	Out2	10	3.3	C6	J4
C7	J8	J9	32	1.11	C7	J8
C8	J7	J9	32	2.4	C8	J7
C9	J9	Out3	17	2.7	C9	J9
C10	J10	J11	41	1.2	C10	J10
C11	J11	Out4	10	1.8	C11	J11
C12	J12	J13	31	1.13	C12	J12
C13	J13	Out5	15	2	C13	J13
C14	J14	J15	27	1.13	C14	J14
C15	J15	Out6	13	2	C15	J15
C16	J17	J15	27	1.13	C16	J17
C17	J16	J18	37	1.8	C17	J16
C18	J18	J19	31	2	C18	J18
C19	J19	Out7	17	2.3	C19	J19
C20	J20	Out8	16	2.7	C20	J20

3.4 Scenario 2: Simulation with proposed network 1

In this scenario, there are also 20 conduits; C1 to C20. The results were completely disappointing, as the condition of all conduits was of the same size, which prevented proper drainage design and increased drainage as water flowed back through the conduits. In Scenario 2, not only the two profiles from Scenario 1, but also the four rising profiles as fraudulent water profiles increased. These four profiles flowed in the opposite direction from downstream to upstream. Also, the first two water profiles were under the same conditions as in Scenario 1. After running two simulations, a satisfactory solution of a strange water profile was found. This water profile required changing the receiver junction of the largest sub-catchment in the study area. If the receiver junction of that sub-catchment changed, the flow profile can be trued by the discharge from that sub-catchment flowed into the relevant junction. The results of Scenario 2 are described in table 5.

Table 5: The results of scenario 2

Conduit	Inlet node	Outlet node	Elevation	Constant Size		
				Depth(ft)	Width(ft)	Length(ft)
C1	J1	Out1	40	1.5	3	727
C2	J2	J1	47	1.5	3	862
C3	J3	J1	47	1.5	3	967
C4	J5	J4	41	1.5	3	949
C5	J6	J4	41	1.5	3	908
C6	J4	Out2	10	1.5	3	1746
C7	J8	J9	32	1.5	3	973
C8	J7	J9	32	1.5	3	733
C9	J9	Out3	17	1.5	3	868
C10	J10	J11	41	1.5	3	705
C11	J11	Out4	10	1.5	3	1040
C12	J12	J13	31	1.5	3	721
C13	J13	Out5	15	1.5	3	1013
C14	J14	J15	27	1.5	3	701
C15	J15	Out6	13	1.5	3	1003
C16	J17	J15	27	1.5	3	971
C17	J16	J18	37	1.5	3	1055
C18	J18	J19	31	1.5	3	1177
C19	J19	Out7	17	1.5	3	759
C20	J20	Out8	16	1.5	3	752

3.5 Scenario 3: Simulation with proposed network 2

All conduits are also designed in size using the best hydraulic section method in Scenario 3 and have excellent drainage to control drainage from all sub-catchments, one of the urban flood control methods. The upstream conduit had a maximum depth of 2.4 feet and a width of 4.8 feet, while the downstream conduit had a maximum depth of 2.7 feet and a width of 3.4. These conduits will be changed to 2.5 feet and 5 feet because the size of conduit 8 and the size of C9 are 3.6 feet and 7.2 feet in scenario 3. Another flow network has three conduits in the flow and a sub-catchment receiver junction needed for the change because the central conduit of the flow network was not released from the subcatchment of this flow network. Initially, junctions that received drainage from the largest subcatchment in the study area were mistreated. Therefore, the discharge from the subcatchment flowed into a different junction not the same as the above scenarios. After changing the receiver junction and adjusting the size of the conduit in that sub-catchment, the conduit overflow was gone and the water level profile results were good. Other drains were designed with a size to improve the condition of the drain and prevent overflow. The results of Scenario 3 are described in table 6.

Table 6: The results of scenario 3

Conduit	Inlet node	Outlet node	Elevation	Proper Size		
				Depth(ft)	Width(ft)	Length(ft)
C1	J1	Out1	40	1.6	3.2	727
C2	J2	J1	47	1.2	2.4	862
C3	J3	J1	47	1.4	2.8	967
C4	J5	J4	41	1.5	3	949
C5	J6	J4	41	2.8	5.6	908
C6	J4	Out2	10	3.3	6.6	1746
C7	J8	J9	32	2	4	973
C8	J7	J9	32	2.5	5	733
C9	J9	Out3	17	3.6	7.2	868
C10	J10	J11	41	1.5	3	705
C11	J11	Out4	10	2	4	1040
C12	J12	J13	31	1.5	3	721
C13	J13	Out5	15	2.2	4.4	1013
C14	J14	J15	27	1.5	3	701
C15	J15	Out6	13	2.3	4.6	1003
C16	J17	J15	27	1.8	3.6	971
C17	J16	J18	37	2	4	1055
C18	J18	J19	31	2.4	4.8	1177
C19	J19	Out7	17	3.6	7.2	759
C20	J20	Out8	16	2.4	4.8	752

3.6 Result Analysis

There are two water elevation profiles with backflow to upstream. The first one is from junction 7 to outfall 3. There were two water level profiles flowing into outfall; junction 7 to outfall 3, junction 8 to outfall 3. But the first one had only upstream regurgitation. The other is from junction 16 to outfall 7. In this flow profile, it consisted of three conduits; C17, C18, C19 and the water flow at here did not flow step by step, the downstream conduit overflowed, but the central conduit had free spaces in the drainage. These two profiles are shown in figure 3.3 and 3.4. This error occurred because the drainages were in the wrong sizes and the drainages could not control discharges from each subcatchment.

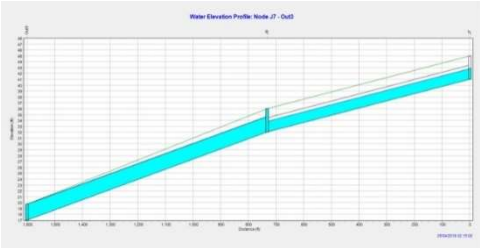

Figure 3.3: Water Elevation Profile of J7 to Out 3 (S1)

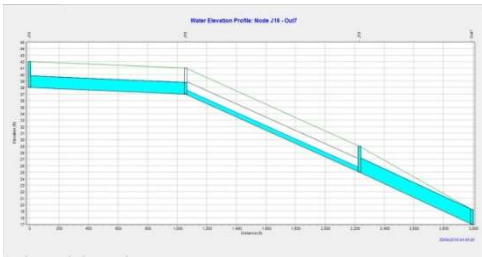

Figure 3.4: Water Elevation Profile of J16 to Out 7 (S2)

The second scenario used a constant conduit size with the best hydraulic section to simulate floods in the study area. Depending on the size of the conduit, the simulation results will vary. But the results were completely disappointing, as the condition of all conduits was of the same size, which prevented proper drainage design and increased drainage as water flowed back through the conduits. In Scenario 2, not only the two profiles from Scenario 1 but also the four water elevation profiles were increased as the wronged water profiles. These four profiles flowed in the reverse direction from downstream to upstream. Also, the first two water profiles were the same as in Scenario 1. These are shown in figure 3.5 to 3.10. After running two simulations, a water profile is a satisfactory solution; junction 16 to outfall 7. This water profile required changing the receiver junction of subcatchment area 17, the largest in the study area. If the receiver junction in that subcatchment changes, the discharges from that subcatchment may flow into another junction and then the flow profile might be trued flow profile.

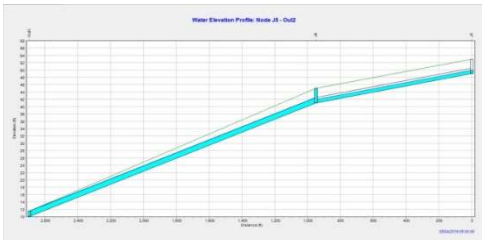

Figure 3.5: Water Elevation Profile of J5 to Out 2 (S2)

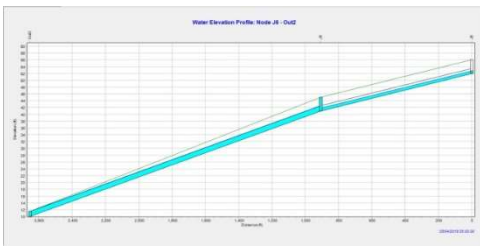

Figure 3.6: Water Elevation Profile of J6 to Out 2 (S2)

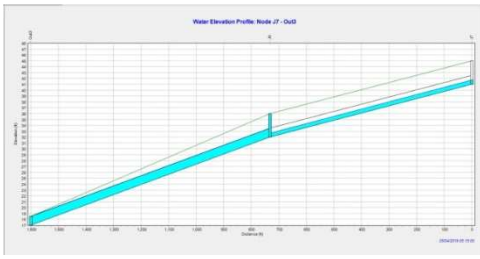

Figure 3.7: Water Elevation Profile of J7 to Out 3 (S2)

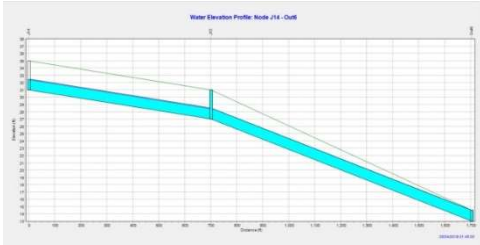

Figure 3.8: Water Elevation Profile of J14 to Out 6 (S2)

Figure 3.9: Water Elevation Profile of J17 to Out 6 (S2)

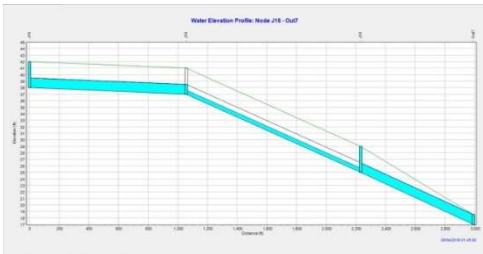

Figure 3.10: Water Elevation Profile of J16 to Out 7 (S2)

After that the last scenario was industriously designed for the size of the drainages. In this scenario, all drainage channels in the study area were designed with optimal hydraulic sections and relocated receiver junctions in subcatchment 17. The last scenario was designed in the sizes of the drainages according to the surface elevation. The flow networks in error were resized in this scenario by the best hydraulic section. And one flow network has three conduits, C17, C18 and C19 respectively. In this flow network, the receiver junction of the sub-catchment had to be changed because the central conduit of the flow network was not released from the subcatchment. After changing the receiver junction of S17 (the largest sub-catchment in the study area) and adjusting the size of the conduits, the conduits no longer overflow and the water level profile results are good.

The drainage size in this scenario was applied as an appropriate drainage design for the study area, as the drainage from each small basin would flow into its own junction and conduit, and eventually through the exit of the river.

In the installation of sustainable urban drainage system(SUDS), green roof system system might be installed as the last procedure in this study.

The study area has 75% roofs and others are asphalt, concrete and lawns. Therefore, as a green roof system, install green roofs in all roofing area of the research. In the situation of using with normal roof, the discharge of the study area is about 0.2314 m3 per second. While using green roofs in study area, the discharge of it changed to 0.1234 m3 per second. So this process slow down the rate of flow and reduce about 35% of the surface water discharge of the building, the demand for cooling and heating, the biodiversity of the research area, improves the durability, air quality of the roof and it can completely control the urban flood of the study area.

4 CONCLUSIONS

In this study, a rainwater management model (SWMM) was used to manage urban stormwater. Using SWMM has simplified the workflow and made it easier to use, saving time and resources. It is also better than manual calculation because it can be simulated in a short time. It can also simulate many things, such as dynamic rainfall runoff and discharge through stormwater channels, waterways and pumps. By using the model, there could be tried experiment with different scenarios before getting the right result, and also can change different inversion levels. The drainage design obtained from the simulation of the model software was used as an appropriate drainage design for the study area.

The installation of the SUDS system (green roof) is obviously effective to be green environment and can be developed not only in reducing and preventing problems, but also in sustainable design of drainage in the study area. In my opinion, there are other options for sustainable urban drainage systems, but the above one is suitable for this research.

RECOMMENDATION

Some of the flooded towns of Yangon City need to apply this research methodology to redesign the appropriate drainage system. In this study, drainage channels and receiver junction sizes were designed. However, it is necessary to design a detention pond as needed. In this study, a maximum rainfall intensity of 9 inches per hour was used, but predictions may make it more appropriate to use a different return period. If emissions from border townships are also applied to the design, the results will give better results. According to the results, the designed drainages are renovated with two sustainable urban drainage systems. However, it is recommended that the other SUDS systems also should be tried in respective cases.

ACKNOWLEDGEMENTS

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A Comprehensive Review of Cooling Systems for Agicultural Greenhouse

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Abstract: Greenhouses are widely used in agriculture cultivation both in hot and cold climates. The essential benefits of the greenhouse are high energy efficiency, high quality crops, and ability for growing plants regardless of the external conditions. Cooling systems are considered as the key to create suitable environmental conditions such as inside air temperature and relative humidity for growing plants. Selection of appropriate cooling systems mainly depends on local environmental conditions, type of the crops and economic potential. Established cooling technologies such as natural ventilation, mechanical cooling systems, evaporative cooling, shading and combined cooling systems have been widely used in different agricultural applications. Hence, the purposes of this work are to review the available worldwide cooling technologies for agricultural greenhouses. The details of each system such as system characteristics, application, effectiveness will be presented. The pros and the cons of each technology will also be discussed in terms of energy conservation and environmental friendliness.

Keywords: Agricultural greenhouse, Cooling systems, Natural ventilation, Evaporative cooling

1 INTRODUCTION

The rapid growth of population and the climate change in the last few decades are the challenging to enhance food resources, water, and energy efficiency (United Nations, 2019). In order to get high yield and improved products quality, greenhouses are used in agricultural sector. Greenhouse technology is considered to overcome the problem of extream weather conditions. The greenhouse is one of the most profitable tools as it can provide very high yields when compared to traditional farming (Mohammadi, Ranjbar, & Ajabshirchi, 2018). Cultivation of crops in a completely closed greenhouse has many advantages such as growing seasons can be extended, creating an optimum growing environment, protection from insects and pesticides as well as reduced energy consumption (Katsoulas, Sapounas, De Zwart, Dieleman, & Stanghellini, 2015).

Growing plants in commercial greenhouses has been successfully accomplished in Europe. However, in tropical and subtropical climates stand particular design challenges because of high temperature and high humidity during the summer seasons (Cuce & Riffat, 2016). The target of growing plant in greenhouse is to control microclimate conditions such as inside air temperature and relative humidity appropriate to the cultivation of various crops so cooling technologies are the main key to overcome the extreme conditions inside the greenhouse. Cooling systems are considered as the key to create proper environmental conditions such as inside air temperature and relative humidity for growing plants. Selection of suitable cooling systems depends on the local environmental conditions, type of the crops and economic potential. So, understanding of thermal behavior of the greenhouse helps in the development of suitable cooling systems that give satisfactory performance under all but the most extreme conditions (Kumar, Tiwari, & Jha, 2009).

Mechanical cooling technologies have been extensively used in hot climates but this technology requires a large amount of energy. Natural ventilation is one of the best ways to reduced energy used for cooling operation in greenhouse. Combination of exhaust fans or screen shading can be used to avoid the direct solar radiation that is unnecessary to the plant's requirements. In those areas where the maximum ambient temperature not exceeds 33°C, the combination of ventilation and shading can play a role well (Ghoulem, El Moueddeb, Nehdi, Boukhanouf, & Kaiser Calautit, 2019). However, in the areas where ambient temperature in summer normally exceeds 40°C, evaporative cooling can work well. The evaporative cooling system can lower inside temperature notably below ambient air. The evaporative cooling system generally consists of fans on sidewall and pad on another sidewall of the greenhouse. Roof cooling systems can also be used. In addition, there are many other cooling systems such as solar powered systems, geothermal heat pump which can be used for cooling of the greenhouses.

In this paper, a comprehensive review of cooling systems for agricultural greenhouse available in literatures is presented. Advantages and disadvantages of each technology is discussed in detail.

2 GREENHOUSE COOLING SYSTEMS

In the hot regions, there are various types of greenhouse cooling methods and systems such as mechanical, ventilation, evaporating by fan-pad, mist/fog and roof cooling, hybrid cooling and integration with PV panels. Besides, it is necessary to find novel, cheap cooling technology for greenhouse suitable for tropical climates. Development of applicable cooling technologies is an important research struggle.

2.1 Mechanical cooling systems

This system is one of the most widely used in hot regions with high ambient temperature and solar levels. Mechanical cooling systems consist of utilizes fan, heat pumps, and heat exchanger which can remove heat from a location. Many studies were carried out to asses and investigate greenhouse mechanical cooling systems in hot regions. The summary of mechanical cooling systems from literature review is given in Table 1.

Table 1: Summary of mechanical cooling systems from literature review

References	Location	Methodology	Results
(Guo et al. 2011)	Shanghai, China	-An experimental set up of air source heat pump water heater (ASHPWH) - Optimizing operation which takes into account thermostatic and timing control patterns	- The average COP (Coefficient of performance) ranged from 2.82-5.51 under typical conditions - Water temperature should be set higher than 46°C in summer and 50°C in another season

References	Location	Methodology	Results
(Limi et al. 2012)	Abashiri Yamagata Tokyo Kagoshi-ma, Japan	- Air conditioning with cool storage tank and three heat pump systems: air source-air supply, water source-air supply and water source-water supply	- The water source-water supply heat pimp could reduce heat than the water source-air supply the heat pump.
(Yang and Rhee 2013)	Hwasung, South Korea	- Evaluated the greenhouse system performance that capture and use surplus air thermal energy for cooling and heating in greenhouse farming	- The energy conservation ratio from operating system can be improved by choosing plants for cold climate and proper weather conditions.
(Katsoulas et al. 2015)	The Netherlands Greece Algeria	- Investigated the effects of cooling system capacity on ventilation requires of semi-closed greenhouse and simulated for many cooling system capacities	- The increase of cooling system capacity can reduce the water used and improve microclimate.

In the previous studies, mechanical cooling systems for greenhouses to be fully closed with increasing cooling system capacity resulted in improve microclimate, water consumption, and increased crop yields. However, this system is a major consumer of energy and return poor investment in hot regions. Moreover, some technologies are cumbersome and require costly maintenance.

2.2 Natural Ventilation

Natural ventilation is one of the techniques to reduce the difference between outside and inside air temperature. Natural or passive ventilation requires very little external energy and equipment. It depends on the difference in pressure, which the outside wind or the greenhouse temperature creates, between the greenhouse and the outside environment (Sethi & Sharma, 2007). If the greenhouse is installed with ventilation opening, both near the ground and roof, then the external cool air enters the greenhouse as shown in blue arrows in Fig.1 through the lower side opening while the external warm air exits though the roof opening as shown in orrange arrows because the density difference so the method causes the lowering temperature in greenhouse. In this section, researches had been carried out to investigate the influence of natural convection on microclimate of the greenhouse in hot regions. The summary of natural ventilation from literature review is shown in Table 2.

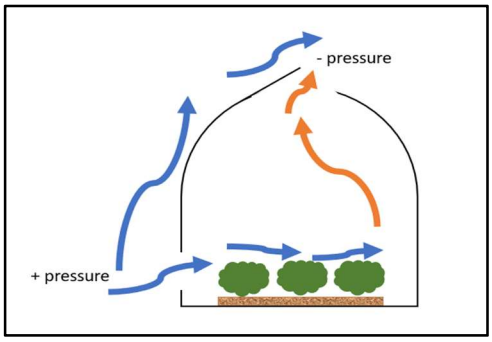

Fig 1: Showing natural ventilation process in the greenhouse

On the application of natural ventilation for temperature and humidity control of the greenhouse, it depends on the various factors including the environment conditions, type of the crops, greenhouse orientation, the size and positioning of the opening vents. So, all of these factors should be considered to analyze and optimize the ventilation performance. In the area with low wind speed, side wall vents can be combined with roof to improve natural ventilation. Future analysis of natural ventilation greenhouse should consider the effect of the surrounding structures as it can affect the ventilation performance. In the hot regions, this method may not be sufficient to lower indoor temperature during the peak condition, so it is necessary that which can be combined with other cooling methods such as evaporative cooling (Ghoulem et al., 2019). In advances study, the design of natural ventilation of greenhouse is providing improved control of temperature, humidity as well as lower cost.

Table 2: Summary of natural ventilation from literature review

References	Location	Methodology	Results
(Ould Khaoua, Bournet, Migeon, Boulard, & Chassériaux, 2006)	France	- Developed a two-dimensional model using computational fluid dynamics technique to determine the effect of wind speed and roof vent opening configuration on airflow and temperature patterns	- The numerical model was successfully validated against ventilation rate and windward roof vent configuration generates the highest ventilation rate
(Teitel, Liran, Tanny, & Barak, 2008)	Israel	- Carried out a naturally ventilated greenhouse with continuous screened side vents	- The wind direction importantly affected the ventilation rate, airflow and plants temperature distributions
(Teitel, Baeza, & Montero, 2012)	Spain	- Investigated a new design greenhouse that had a 30° roof slope with side wall vents and roof vents performance that	- New design greenhouse could provide ventilation rate up to 4 times

References	Location	Methodology	Results
		capture and use surplus air thermal energy for cooling and heating in greenhouse farming	higher than the paral greenhouse - Can improve air circulation and temperature in the greenhouse
(Espinoza et al., 2017)	Spain	- Evaluated the influence of ventilation configuration on the flow pattern in multi-span greenhouse	- Two roof and side vents configuration improved air movement at the crop zone but the overall volumetric flow rate was lower than the three roof and side vents - The surrounding greenhouse on the leeward side decreased the ventilation capacity

2.3 Evaporative cooling

Evaporative cooling is one of the most potential technologies for providing suitable weather conditions of the greenhouse in hot climates. These systems are based on conversion of sensible heat into latent heat of evaporated water with water supplied mechanically (Sethi & Sharma, 2007). During the process, water supplied directly into the greenhouse by mist or fog system, sprinklers and fan-pad evaporative cooling. The technique can significantly decrease temperature below the ambient temperature and increase humidity inside the greenhouse. The systems include with fan-pad system, fog/mist system and roof cooling system as follows.

2.3.1 Fan-pad system

This system generally consists of fans on sidewall and pad on another sidewall of the greenhouse. The principle of this system is applied by running water over the pad and consequent withdrawal of air through it by fans on the opposite side as shown in Fig. 2. Fan-pad cooling produces two changes in the condition of the air exiting the pads (Sethi & Sharma, 2007). During the process, air temperature becomes cooler and its humidity is also raised. Over the past decades, many studies of fan-pad system for cooling the greenhouse have been introduced and the summary of fan-pad cooling system from literature review is given in Table 3.

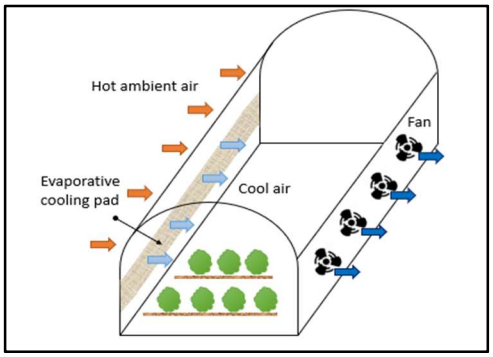

Fig 2: Schematic view of fan-pad cooling system

Table 3: Summary of fan-pad system from literature review

References	Location	Methodology	Results
(Jain & Tiwari, 2002)	Delhi, India	- Developed mathematical model to study thermal behavior after evaporative cooling and experimental studies of fan-pan system	- Air temperature in the greenhouse was below 4-5°C against ambient temperature - The optimum parameters of evaporative cooling system are the length of the greenhouse as 6 m. and the height of cooling pad as 1.75 m. which were sensitive to cooling
(Ganguly & Ghosh, 2007)	Kolkata, India	- Developed a thermal model of a greenhouse based on fan-pad evaporative cooling and analyzed thermal performance compared with a reference	- This system was the most effective during summer months. However, in the monsoon it was less effective because of high relative humidity of ambient air
(Ahmed, Abaas, Ahmed, & Ismail, 2011)	Khartoum Sudan	- Evaluated the performance of three types of evaporative cooling pads: celdek pads, straw pads and sliced wood pads	- Straw type pads provide the highest temperature decreased while the sliced type wood pads provided the lowest
(Romantchik , Ríos, Sánchez, López, & Sánchez, 2017)	Texcoco, Mexico	- Developed a model to determine the energy required by a fan-pad system in span type greenhouse	- The grid-connected photovoltaic system was able to generate all the energy consumed

From the reviewed literatures, it can be said that the fan-pad system can effective for the greenhouse cooling and humidification in hot climates. In order to achieve optimum cooling, water flow rate and distribution system, capacity of pump, recirculation and output rate of the system must be carefully calculated and designed to provide adequate wetting of the pad and to avoid accumulation of pads. In addition, this system may achieve by the combination fan-pad

with other systems such as shading screen in terms of cooling achievement. However, there are many disadvantages of fan-pad systems: temperature and humidity distributions will be uneven across the greenhouse. It may be not effective in those areas where high humidity and increased maintenance of greenhouse operation.

2.3.2 Fog/mist system

This system provides spraying water as small droplets through tiny nozzles to create micro-fine mist above the crops. Cooling is achieved by evaporative of droplets. Fogging can also be used to create increasing relative humidity beside from cooling greenhouse (Kumar et al., 2009). Many studies were carried out to investigate fog and mist systems for greenhouse, and the summary of fog/mist system from literature review is shown in Table 4.

Table 4: Summary of fog/mist system from literature review

References	Location	Methodology	Results
(Katsoulas, Kitta, & Kittas, 2006)	Epirus, Greece	- Studied the influence of a fog system on microclimate, crop transpiration rate, quality and yield of soilless pepper crop	- Fog system can lower inside air temperature and leaf temperature by up to 3°C compared to natural ventilation and improved the mean crop weight and percentage of marketable crops - It reduced greatly the total number of fruits per plant
(Linker, Kacira, & Arbel, 2011)	Bet-dagan, Israel	- Developed a climate control system for a small greenhouse equipped with variable-pressure fogging system and variable-speed extracting fans	- The controller can maintain indoor greenhouse conditions near the set point
(Sánchez-Hermosilla, Páez, Rincón, & Callejón, 2013)	South-eastern, Spain	Experimentally investigated a fogging system for applying plant-protection products and used twin spray nozzle as compared to manual spray	- Air-water spray led to a deposition in plant canopy that increased as the plants develop

From the reviewed studies, it can be seen that fog and mist system can achieve high efficiency of water evaporation while also keeping leaf dry. Moreover, fog system can lead a more uniform distribution and humidity in a greenhouse as compared to natural ventilation with roof opening (Katsoulas, Kittas, & Bartzanas, 2012). However, there are disadvantages when compared to the fan-pad evaporative cooling system such as the lower air saturation efficiency, cost, water and energy consumption.

2.3.3 Roof evaporative cooling

Roof evaporative cooling is sprinkling water onto the surface of roof so as to form a thin layer which results increasing of free water surface area so increases the evaporative rate. This causes water temperature to reduce to wet bulb temperature of the nearly ambient air. The summary of roof evaporative cooling from literature review is shows in Table 5.

Table 5: Summary of roof evaporative cooling from literature review

References	Location	Methodology	Results
(Willits & Peet, 2000)	North California USA	- Carried out an experimental study of cooling performance of greenhouse with water sprinkling and shade cloth	- The rise of the air temperature and electricity consumption was reduced by up to %41and %21 when using roof evaporative cooling
(Ghosal, Tiwari, & Srivastava, 2003)	Delhi, India	-Developed the mathematical model of an uneven span greenhouse and applied water flowing on a shade cloth stretched over the roofs and south wall	-Greenhouse temperature was decreased by 6°C and 2°C in shaded with water flow and shaded configurations
(Helmy, Eltawil, Abo-Shieshaa, & El-Zan, 2013)	Kafr Elsheikh, Egypt	- Studied the performance of an evaporative cooling greenhouse with roof evaporative cooling using two identical small-scale greenhouses	- Inside air temperature of greenhouse which operated under combination of roof water flow and fan-pad system was less than that for fan-pad greenshouse

Based on review of literatures, this system may not be suitatle in the areas where lack water due to the reduction in temperature will require a lot of water. roof evaporative cooling has limitation in terms of durability of roof material. Future work should focus on the material utilized for roof, evaporating media, flow speed of water, and more work is significant to assess its performance under the real conditions.

2.4 Combined cooling system

One cooling system may not be sufficient to provide the optimum weather conditions under hot and dry regions. To achieve the optimal greenhouse cooling in hot climates, cooling techniques can be combined. As an example, combined cooling systems and the components of

greenhouse are shown in Fig. 3. Combined or hybrid technique can decrease energy consumption while improving greenhouse cooling performance. During the last years, many researchers have studied combinations of different cooling techniques and the summary of combined cooling system is given in Table 6.

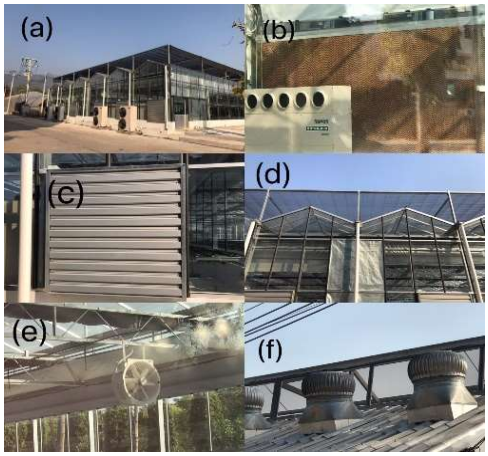

Fig 3: Photographic view of the greenhouse and main components (a) external view; (b) evaporative cooling pad; (c) extracting fan; (d) external shading net; (e) circulation fan; and (f) ventilation fan

Table 6: Summary of combined cooling system from literature review

References	Location	Methodology	Results
(Xu, Li, Wang, Liu, & Zhou, 2015)	Shanghai, China	-Investigated the performance of evaporative cooling pads systems combined with shading and ventilation	- Fan-pad cooling system is an effective option for greenhouse cooling even in humid climates
(Banik & Ganguly, 2017)	India	- Developed a thermal model a distributed fan-pad evaporative cooler coupled with solar desiccation	- Coupling desiccants with evaporative cooling provide improved cooling effect with the maximum temperature in greenhouse - This system is less effective when the ambient relative humidity increases
(Tataraki, Kavvadias, & Maroulis, 2019)	Greece	- Designed the combined cooling, heating and power generation (CCHP) systems together with the greenhouse	- The cogeneration is a cost-effective solution to improve the economic and energetic efficiency of the facility

From the reviewed studies, it can be seen that the combination and simultaneous usage of natural ventilation, evaporative cooling and shading has significantly potential to reduce energy consumption and provide proper indoor conditions for crop cultivation. However, combined cooling systems must be assisted by an effective controller to ensure that temperature, relative humidity and distributions are maintained in greenhouse.

2.5 Solar powered cooling

In order to reduce energy costs, solar powered systems for the greenhouse cooling in hot regions have been proposed and the summary of solar powered cooling from literature review is presented in Table 7.

Table 7: Summary of solar powered cooling from literature review

References	Location	Methodology	Results
(Hassanien, Li, & Dong Lin, 2016)	Various Countries	- Reviewed the solar energy application technologies in agricultural greenhouses	- PV (Photovoltaics) systems and solar thermal systems would be suitable choices for cooling greenhouses especially for remote and desert areas
(Abu-Hamdeh & Almitani, 2016)	Saudi Arabia	- Applied solar energy and liquid desiccant to provide evaporative cooling systems of greenhouse in high ambient humidity climate	- The desiccant evaporative cooling system lowered the average daily temperatures by up to 6°C as compared to conventional evaporative cooling system
(Yildirim & Bilir, 2017)	İzmir, Turkey	- Evaluated a renewable energy option for greenhouse which consisted of ground source heat pump power by grid connected solar PV panels	- PV electricity generation can meet 33-67% of greenhouse demand during summer months

From previous studies on solar powered cooling, it can be said that the application of solar energy improves overall energy efficiency and decreases energy costs. In addition, this system can be combined with ground source heat pump in order to optimize greenhouse cooling in hot regions.

However, in humid regions, this system can be combined with desiccant assisted cooling systems in order to provide the heat requirement for regenerating the desiccant. Table 8 shows the summary of worldwide cooling greenhouse systems in hot conditions.

Table 8: Summary of greenhouse cooling system

System	Advantages	Disadvantages
Mechanical Cooling systems	- Increasing in capacity of cooling system resulted in improve microclimate, water consumption, and increased crop yields	- A majority consumer of energy - Costly maintenance - Complexity technology
Natural ventilation	- Simple technology - Inexpensive technology - Can provide comfortable conditions for crops - Uniform air velocity distribution inside greenhouse	- May not be sufficient to lower indoor temperature during peak conditions No humidity control
Evaporative cooling systems	- Low cost - Environment friendly system - Low energy consumption - Simple technology	- Temperature and humidity distributions will be uneven across the greenhouse - Limited air temperature decrease - Short-life cycle of pads - No humidity controls
Combined cooling system such as Evaporative cooling with naturally ventilated etc.	- Simple technology - High evaporative cooling potential - Uniform air distributions in greenhouse	- Cannot lower temperature to low values - Costly maintenance - No humidity controls
Solar powered cooling	- Energy saving -Environmentally friendly - Less maintenance - Improve overall energy efficiency	- The initial cost of purchasing a solar system is fairly high - Long payback period

In terms of cooling capacity and temperature/humidity controls, mechanical cooling systems are as the most effective as solar powered cooling system for cooling in agricultural greenhouse in hot regions. Next, Combined cooling system, evaporative cooling and natural ventilation respectively. However, in terms of energy use, natural ventilation uses less electricity requirements followed by evaporative cooling system, combined cooling system, solar powered cooling and mechanical cooing system respectively.

3 CONCLUSIONS

This paper presented the available worldwide cooling technologies for agricultural greenhouses in regions with hot climates. The detailed review presented in this paper highlighted that none of the currently available technologies that can provide all cooling requirements of the greenhouse is perfect. The selection of system is based on many parameters such as greenhouse location, cost, type of the crops, and so on. Therefore, the most properly cooling greenhouse technology is that meets most desired conditions of the farmer to grow off-season crops in order to fetch maximum yields. There is essential to improve the cost and effective technology appropriate to local climatic conditions. Based on critical review of works of various researchers, it can be seen that the combination of natural ventilation, evaporative cooling and shading has potential to decrease greenhouse energy requirement and provide suitable conditions for crop production throughout the year. For the future works, the research should be focused on greenshouse design, variations of microclimate in different shapes and understanding of thermal behavior of the greenhouse. Moreover, the research should be considered about new cladding materials to reduce heat load.

Finally, the delvelopment of cooling technology suitable for tropical and subtropical is neccessary for effective cooling performance in local conditions. This would eventually reduce both capital costs and operating costs.

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The Effect of Conventional Sugarcane Planting Periods on Soil Properties

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Abstract: The objective of the research is to evaluate the effect of the conventional sugarcane planting on soil properties of sugarcane plantation in Bunthan Sub-district, Suwanakhuha District, Nongbua Lamphu. From the past to the present, herbicides have been widely used during sugarcane planting. In this study, soil samples were collected from 5 different locations which had various durations of sugarcane planting. Soil samples were collected from 3, 5, 7, 9 and 18 years of sugarcane planting to determine the effects of planting in conjunction with herbicides usage on soil properties. In addition, soil samples were also collected from lands that have stopped from sugarcane planting for 1 and 3 years in order to see the change of soil properties after stopping of planting. Total of 7 soil properties were analyzed, these parameters are pH, electrical conductivity, soil organic matter, cation exchange capacity, nitrogen, phosphorus and potassium. The results showed that some decreasing of soil organic matter and cation exchange capacity were seen. Soil samples with 9 and 18 years of sugarcane plantings had lower soil organic matter than their reference soil by 48.5% and 26.9% respectively. Soil samples with 3 years of switching from sugarcane planting had higher soil organic matter and cation exchange capacity than the soil that had stopped from sugarcane planting for 1 year.

Keywords: Herbicide, Soil properties, Sugarcane planting

1 INTRODUCTION

Thailand is the world's third largest exporter of sugar cane has exported 2.6 million tons of raw sugar, about 1,120 million US$ (FAOSTAT, 2017). Sugarcane is an important economic crop in the country, it is the raw material used in the sugar factories and renewable energy. Currently, Thailand has more than 4 million acre of sugarcane plantations. Due to the government has a policy to expand the area of sugarcane planting and reduce the area of the rice planting (OAE, 2019) and it is an increase in sugar factories in Thailand every year. In 2019, Thailand has increased sugarcane plantation area by 6.01 percent from all sugarcane plantation areas on 47 provinces. Northeastern is a major sugarcane plantation areas in Thailand with a total area of 2 million acre. Suitable areas for sugarcane planting is moderate with annual rainfall about 1,452 mm. (OCSB, 2019).

Nongbua Lamphu is a province in northeastern Thailand, with total area of 952,711 acre, over 50 percent are agricultural area. Farmer is the primary occupation and sugarcane is the primary crops. In 2019, Nongbua Lamphu has 122,643 acres of sugarcane plantation and the annual crop yield is 3,663,764 tons (OCSB, 2019). However, the farmers usually apply herbicide in sugarcane planting to control weeds at the beginning of the crop. Thailand has imported herbicides to 125,280 tons by 2019. Herbicides have been widely used in large quantities in sugarcane planting, sometimes exceed the suggestion dosages. Due to herbicides such as paraquat have good solubility properties (Eisler, 1990) cause this herbicide to be leached, contaminated and remained in soil and water. It later could be harmful to the health of the locals such as cancer and neurodegenerative (Bassil et al., 2007; Parrón et al., 2011). Therefore, it is crucial to control herbicide in environment.

Sugarcane can grow in any soil type. The suitable soil are sandy loam, silt loam and clay loam because their high water permeability. The suitable soil pH is between 5.6 to 7.3. Soil Organic Matter (OM) is in the range of 3 to 5%. The suitable Phosphorus (P) and Potassium (K) is greater than 10 mg/kg and 80 mg/kg, respectively. Cation exchange capacity (CEC) is preferably greater than 15 cmol(+)/kg and the Electrical Conductivity (EC) is less than 0.4. dS/m.

This research aims to evaluate the effect of length of conventional sugarcane planting on soil properties.

2 MATERIALS AND METHODS

2.1 Description of The Study Sites

In this study, soil samples were collected from 2 different scenarios:

- The soil has been used for sugarcane planting in conjunction with herbicide for 3, 5, 7, 9 and 18 years. Currently, the farmers are still planting sugarcane on that land. The herbicide is applied before planting and before sugarcane starts to grow. When sugarcane is 2-3 months old, the usage of herbicide is stopped;
- The soil that had been used for sugarcane planting, and has stopped for 1 and 3 years. Currently, the soil that has stopped from sugarcane planting for 1 year is rice paddy field without herbicide usage. The soil that stopped from sugarcane planting for 3 years, two sampling sites; chili growing and abandon land.

2.2 Sampling Method

Samples were collected to cover the entire area of interested. The total sampling points were 15-20 points per plot. Use the hoe or spade to dig the soil about 15 centimeters deep and collected sample of 1 kilogram per point. The soil samples were mixed together to ensure that soil sample has homogeneous properties. Spread soil sample into a circle. Divide the soil into 4 equal parts and select only 1 part of the soil sample required in quantity of 1 kilogram. Finally, pack the soil into a zip lock bag and record the sample details (IDD, 2019). All samples were collected during sugarcane planting seasons within less than 24 hours apart. Analyzed parameters are pH, electrical conductivity (EC), organic matter (OM), cation exchange capacity (CEC), total nitrogen (N), phosphorus (P) and potassium (K). Soil pH was measured by pH meter with a soil:water ratio of 1:2. Electrical conductivity (EC) was measured by EC meter with a soil:water ratio of 1:5. Soil organic matter (OM) was determined by Walkley & Black method, cation exchange capacity (CEC) was determined by NH_4OAC pH7/distillation method, total nitrogen (N) was determined by Kjeldahl method, phosphorous (P) was determined by Bray ll extraction method and potassium (K) was determined by NH_4OAC pH7/AES method.

All 18 samples were 5 soil samples from conventional sugarcane plantations, 4 soil samples from lands that had stopped from sugarcane planting and reference soils. Reference

soil is the soil collected in the same area as aforementioned 9 samples, the reference soil is the soil in the same proximity but has never been used for planting and never been exposed to herbicide such as soil next to the house.

3 RESULTS AND DISCUSSION

The properties of soil samples from different sampling location is shown in Table 1.

Soil pH is a characteristic that describes the relative acidity or alkalinity of the soil. The pH is a parameter that affects the growth and yield of plants (USDA, 2014). The suitable pH for sugarcane planting is ranging from 5.6 to 7.3. Figure 1 shows the difference in pH values which are between 6.13 to 8.03 and the average soil pH is 7.05, indicating that soil samples were slightly acidic to moderately alkaline. Compared to the suitable soil for sugarcane planting, the soil used in sugarcane planting for 18 years and the soil that stopped sugarcane planting for 3 years was not suitable for sugarcane planting with pH 8.03 and 7.65 respectively.

Soil organic matter (OM) is the parameter expressing fertility of the soil, the preferable OM for sugarcane planting is between 3 - 5%. The average OM of these soil sample is 3.29% which is fairly suitable for planting while the minimum OM is 1.47%. The data shows that cultivated soils for 9 and 18 years had less OM than the reference soils and lower than suitable OM for sugarcane planting at 2.48% and 1.85%, respectively. Figure 2 shows that increasing of planting time in conjunction with herbicides related to the lower OM than reference soil for soil sample 9 and 18 years. The OM increased when the soil stopped growing sugarcane and stopped using herbicides. Soil OM might have been utilized and decreased in sugarcane growing and using of herbicides.

Table 1: Description the properties of soil samples for sugarcane planting in conjunction with herbicide usage during plantation and soil that stopped sugarcane planting in conjunction with herbicide usage during plantation.

Soil samples	pH	OM (%)	EC (dS/m)	CEC cmol(+)/kg	N (%)	P (mg/kg)	K (mg/kg)
Soil sample for sugarcane planting of 3 years.	7.01	2.95	0.18	23.78	0.14	4.98	54.19
Reference of soil sample for sugarcane planting of 3 years.	6.13	2.89	3.67	22.39	0.28	19.14	233.21
Soil sample for sugarcane planting of 5 years.	6.55	3.24	0.15	36.54	0.16	1.89	21.43
Reference of soil sample for sugarcane planting of 5 years.	6.64	2.16	0.19	19.49	0.1	2.40	22.62
Soil sample for sugarcane planting of 7 years.	6.44	3.41	0.17	19.14	0.14	3.05	28.12
Reference of soil sample for sugarcane planting of 7 years.	7.83	3.08	0.29	22.04	0.13	20.13	76.83
Soil sample for sugarcane planting of 9 years.	7.27	2.48	0.23	14.85	0.11	14.08	78.29
Reference of soil sample for sugarcane planting of 9 years.	6.62	4.82	0.35	19.26	0.21	14.08	121.05
Soil sample for sugarcane planting of 18 years.	8.03	1.85	0.21	25.06	0.09	1.18	79.00
Reference of soil sample for sugarcane planting of 18 years.	7.20	2.53	0.41	21.58	0.12	4.38	249.64
Soil stopped sugarcane planting 1 years (Chili planting).	6.90	1.47	0.26	14.62	0.06	5.92	48.10
Reference of soil stopped sugarcane planting 1 years (Chili planting).	7.39	5.29	1.61	23.20	0.25	23.78	470.00
Soil stopped sugarcane planting 3 years (Rice planting).	7.65	2.86	0.46	23.78	0.15	50.65	184.00
Reference of soil stopped sugarcane planting 3 years (Rice paddy).	7.39	5.29	1.61	23.20	0.25	23.78	470.00
Soil stopped sugarcane planting 3 years.	6.33	3.03	0.12	24.13	0.14	3.52	17.24
Reference of soil stopped sugarcane planting 3 years.	7.39	5.29	1.61	23.20	0.25	23.78	470.00

Soil salinity assessment is based on measurements of the electrical conductivity (EC) (Rhoades & Corwin, 1990). Soil salinity affects the growth of plants and the quality of sugar. Each plant. can endure the different soil salinity. Plants that grow in soil with high salinity often die or lack of water, despite adequate water (Arunin, 1996). The optimum soil EC for sugarcane is 0.4 dS/m. The average EC of soil sample is 0.72 dS/m while Figure 3 shows the maximum EC is reference soil that used to sugarcane planting in conjunction with herbicide usage during plantation for a period of 3 years and values is 3.67 dS/m. The soil sample from 18 years of sugarcane planting and the soil that has stopped sugarcane planting for 3 years have a suitable EC of 0.41 and 0.46 dS/m, respectively. Cation exchange capacity (CEC) is the ability to exchange cations of soil. If the soil has a high exchangeable positive charge capacity, it can absorb more nutrients. Plant roots will be able to use more nutrients. The suitable CEC for sugarcane planting should be greater than 15 cmol/kg. The average CEC of the sample is 22.26 cmol/kg and the minimum is 14.62 cmol/kg. Figure 4 shows that lower CEC were found in soil cultivation of sugarcane for 9 years and the soil that has stopped from sugarcane planting for 1 year, the CEC were 14.85 and 14.62 cmol/kg, respectively. The decreasing of CEC were found in soil samples that have planted sugarcane for 7 and 9 years and the soil that stopped from sugarcane planting for 1 year. CEC relates to the amount of OM in the soil. If the CEC is high, it means that it has a high value on OM (Meimaroglou & Mouzakis, 2019). Two samples of the soil with a reduced CEC found that the OM also decreased.

Total nitrogen is an important nutrient for plant growth (USDA, 2014). Soil with nitrogen higher than 0.15% is considered as high nitrogen soil. If the value is less than 0.05%, it is very low nitrogen. Therefore, low-nitrogen soils should be added with fertilizer. The average total nitrogen of soil samples is 0.16% and the minimum is 0.06%. Figure 5 shows that soil cultivation of sugarcane with herbicides for 18 years and the soil that stopped sugarcane planting for 1 year had low nitrogen, with nitrogen of 0.09% and 0.06%, respectively. Soil samples with suitable nitrogen for sugarcane planting were found in the soil cultivation of sugarcane with herbicides to 5 years and the soil that stopped sugarcane planting with herbicide for 3 year (currently is chili planting), with the 0.16% and 0.15% respectively.

Phosphorus is a primary nutrient for plants. It affects the growth of plant roots and flowers. Phosphorus suitable for sugarcane is more than 10 mg/kg. The average phosphorus in soil sample is 13.54 mg/kg and the minimum is 1.18 mg/kg. Figure 6 shows that most of soil samples have low phosphorus, except the soil cultivation of sugarcane with herbicides to 9 years, the soil that stopped sugarcane planting with herbicide for 3 year (Chili planting) and reference soil. High phosphorus in soil could occur from herbicide (Mingjing, Hui, & Deb, 2019). It can produce more phosphorus than phosphorus obtained from fertilizer. However, it may be found that phosphorus is decreased due to natural complexity and may not be random sampling in the right time causing errors (Mingjing, Hui, & Deb, 2019).

Potassium affects the production quality of plants. Potassium suitable for sugarcane is higher than 80 mg/kg. The average of potassium of these sample is 163.98 mg/kg and a minimum is 17.24 mg/kg. Figure 7 shows that most of soil samples have a lower potassium when compared with the reference soil and suitable soil for sugarcane planting, except the soil that stopped sugarcane planting with herbicide for 3 year (Chili planting) and reference soil.

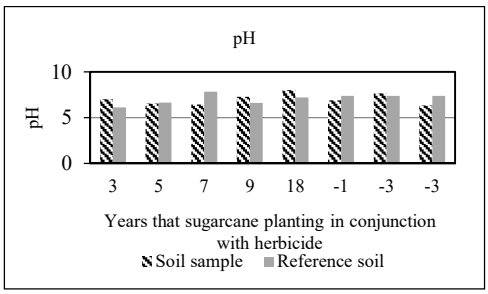

Figure 1: Comparison the pH of soil samples for sugarcane planting in conjunction with herbicide usage during plantation and soil that stopped sugarcane planting in conjunction with herbicide usage during plantation.

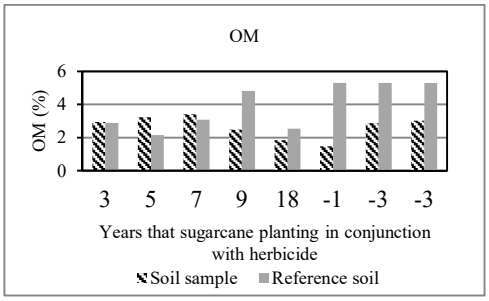

Figure 2: Comparison the OM of soil samples for sugarcane planting in conjunction with herbicide usage during plantation and soil that stopped sugarcane planting in conjunction with herbicide usage during plantation.

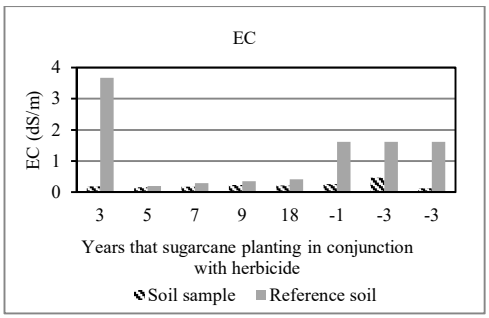

Figure 3: Comparison the EC of soil samples for sugarcane planting in conjunction with herbicide usage during plantation and soil that stopped sugarcane planting in conjunction with herbicide usage during plantation.

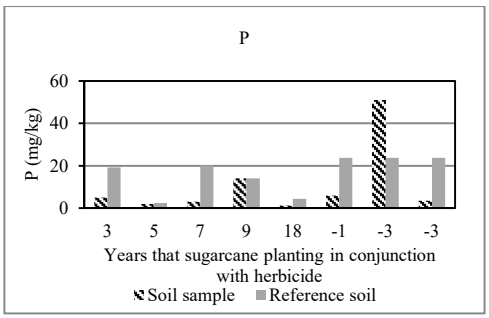

Figure 6: Comparison the phosphorus of soil samples for sugarcane planting in conjunction with herbicide usage during plantation and soil that stopped sugarcane planting in conjunction with herbicide usage during plantation.

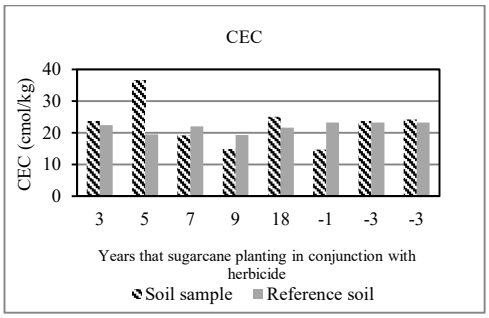

Figure 4: Comparison the CEC of soil samples for sugarcane planting in conjunction with herbicide usage during plantation and soil that stopped sugarcane planting in conjunction with herbicide usage during plantation.

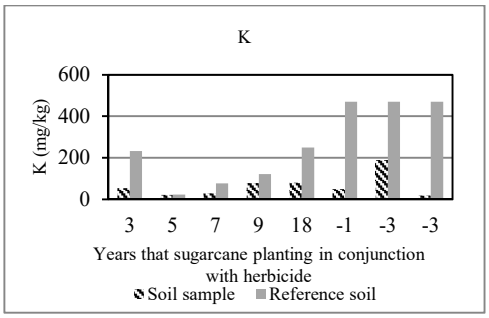

Figure 7: Comparison the potassium of soil samples for sugarcane planting in conjunction with herbicide usage during plantation and soil that stopped sugarcane planting in conjunction with herbicide usage during plantation.

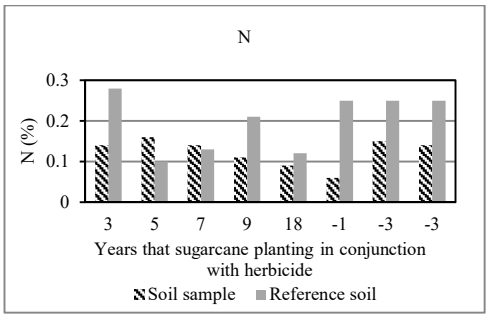

Figure 5: Comparison the total nitrogen of soil samples for sugarcane planting in conjunction with herbicide usage during plantation and soil that stopped sugarcane planting in conjunction with herbicide usage during plantation.

4 CONCLUSIONS

Sugarcane can grow in most soil conditions, but its production depends on soil properties. In this work, soil properties from various sugarcane planting lengths were determined. The results show that organic matter in soil samples of sugarcane planting for 9 and 18 years were lower than their reference soil and they are not suitable for sugarcane planting. Soil samples, from lands that have stopped sugarcane planting for 3 and 1 years, had less OM than their reference soils. The longer period from stopping sugarcane planting, the higher OM in the soil samples. Therefore, the period of time may affect the organic matter is time to stop using the herbicide increases the organic matter will increase accordingly.

ACKNOWLEDGEMENTS

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Bio Smart Farm Management for the Model Community

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Abstract: The objective of this research was to study the management of Bio Smart Farming of Ban Nong Ma Kor Community, Nong Luang Subdistrict, Lan Krabue District Kamphaeng Phet Province. It is a qualitative research using interviews, group discussion and participant observation. The results showed that Ban Nong Ma Kor community had a 40 cubic meter biogas system in the community. There was a gas pipe transporting to another 10 households to solve community problems. And there was magnification of the outcome for the use of pelletizing machine for fish and frogs food, earthworm farming systems for producing manure and fertilizer, along with demonstration plot. There was also an installation of water system commanding by measuring humidity, temperature and acidity. It was to bring digital technology to help developing and upgrading the management of renewable energy which can truly solve community problems. According to the concept of sustainable development divided into 3 dinensions including environment, society and economy. 1. Environment made the community to be better environment without bad smell from livestock farming. That was causing the bad smell in the community. 2. Social improved the relationships of people in the community. The members had cooperation and unity both behavior and idea. 3. Economic could help reducing the cost of purchasing LPG gas and fertilizer for agricultural usage. Also, it would increase revenue from selling organic vegetables, Worm Casting Liquid and also had the opportunity to increase income by allowing those who interested in the study of a Bio Smart Farming Management for community Model to further expand the community development.

Keywords: Smart Farm, Management, Community

1 INTRODUCTION

The environmental problems are considered one of the important problems in Thailand, which problems are water pollution, air pollution problems, garbage problems, water shortage, energy shortage and the problem of contaminated food (Busararat Phanrin, 2013). One of the causes of environmental problems comes from pig farming and livestock farming. (Pollution Control Department, 2016) When there is a large number of raising then will have greater impact on the environment, it also affects people in the neighborhood as well. Therefore is considered an important issue that should be resolved.

Solving the environmental problems resulting from livestock. Biogas Technology is considered a solution to the problem that can reduce the impact that will occur in the environment to a minimum. And is a valuable waste management for maximum benefit (VanLier and the group referenced in Prathin Kullawanit et al., 2007). In addition to biogas technology to help reduce environmental pollution, the biogas obtained can also be used instead of LPG and biomass fuels. In order to save energy and obtaining bio-fertilizer that is beneficial to plants as well the use of biogas technology is therefore an option for communities that help solve environmental problems. It can also help reduce energy imports from foreign countries as a result of increased energy use in Thailand.

The Ministry of Energy has recognized the importance of environmental problems from pig farming and livestock farming. (Pollution Control Department, 2016) therefore, has put a policy to promote the use of biogas in the alternative energy development plan and alternative energy. 2015–2036 By encouraging communities to participate in the production and use of renewable energy extensively And promote and support biogas production at the household level Especially rural communities for the benefit of using in the household It also promotes the development of biogas network in the community to connect the system that may have the capacity to be able to be shared and used in the community, which the community manages themselves

Smart farming is a management concept focused on providing the agricultural industry with the infrastructure to leverage advanced technology including big data, the cloud and the internet of things (IoT) for tracking, monitoring, automating and analyzing operations. Also known as precision agriculture, smart farming is software-managed and sensor-monitored. Smart farming is growing in importance due to the combination of the expanding global population, the increasing demand for higher crop yield, the need to use natural resources efficiently, the rising use and sophistication of information and communication technology and the increasing need for climate-smart agriculture. Smart farming is useful precision agriculture helps reduce overall costs and improve the quality and quantity of products, the sustainability of agriculture and the experience for the consumer. Increasing control over production leads to better cost management and waste reduction. The ability to trace anomalies in crop growth or livestock health, for instance, helps eliminate the risk of losing yields. Additionally, automation boosts efficiency. With smart devices, multiple processes can be activated at the same time, and automated services enhance product quality and volume by better controlling production processes.

Ban Nong Ma Kor Community, Nong Luang Subdistrict, Lan Krabue District Kamphaengphet Province that is one community that has problems caused by livestock. Which is supported by PTT exploration and production Public Company Limited with School of Renewable Energy and Smart Grid Technology Naresuan University has built a 40 cubic meter biogas system to send gas pipes to the community in order to solve community problems. There is also an extension of having a pellet machine for fish and frogs, as well as an earthworm farming system to produce manure and fertilizer, as well as vegetable demonstrations. To bring digital technology to help develop, upgrade the management of alternative energy the researcher is interested to study the management of Bio Smart Farming of the community to be a model for other communities to solve problems and develop the community further.

2 OBJECTIVE

To study the management of Bio Smart Farming of Ban Nong Ma Kor Community, Nong Luang Subdistrict, Lan Krabue District, Kamphaeng Phet Province.

3 RESEARCH METHOD

This research is qualitative research along with Paticipation Action Research:PAR.The samples were selected by purposeive sampling which were community leaders and community members. Data were collected using interviews,discussion groups and participant observation.

4 DATA ANALYSIS

Analyze data by providing content relevant to the research objectives. By bringing to check for accuracy, classifying and organizing the information into categories (Supang Chantawanit, 2014)

5 RESULT

Ban Nong Ma Kor Community, Nong Luang Subdistrict, Lan Krabue District Kamphaeng phet Province There are a total of 150 households and 30 livestock households, of which there are 483 pigs and 57 cows. The community has a foul odor caused by the livestock in the community that has a total of 540 pigs and cows.

PTT Exploration and Production Public Company Limited (PTTEP) has received information about the community suffered. Therefore, working with School of Renewable Energy and Smart Grid Technology Naresuan University to survey the conditions of the area and organizing a forum for brainstorming to find solutions to problems with the community at every step by selecting suitable areas. Which is local in the middle of the village. There is a pig farm participating in the project to build a 40 cubic meter fixed dome biogas system and gas pipelines to 10 households, totaling 11 households.

Figure 1: Fixed dome biogas system of community 40 cubic meter

After that have raised fish, frogs and earthworms and further development by creating a pelletizing machine for fish food and frogs, as well as an earthworm farming system to produce manure and fertilizer, along with vegetable demonstrations. By raising earthworms to get fertilizer, can improve soil quality. Got manure from earthworms for food of fish and frogs and can be sold Including bringing to make pellets and for the production of organic vegetables. There is also a water system commanding system by measuring humidity, temperature, and acidity. Bringing digital technology to help develop, upgrade the management of renewable energy.

Figure 2: Training for earthworms

Figure 3: Fish pond and fish feed pellet systems

There is also a development of Bio Smart Farming management system. Bringing digital system together with energy policy which is Energy 4.0, it is very important that the community has a management system that is easy and quick to communicate with renewable energy technologies that can respond quickly to community needs. Adding a gas viewing system for biodiesel nontoxic vegetable watering control system and feeding the fish with a mobile phone. Moreover, also have a product value increase from the products of the Bio Smart Farming system such as organic vegetables, pellet fertilizer by developing packaging using natural materials for packaging such as leaf scraps, straw scraps, etc. in order to help reduce garbage and use the resources that are most useful. And also safe for health as well regarded as a complete community development in society, economy and environment.

At the interview Mr.Samneang Chandang, the village headman said, "Beginning with a pig raising group. Then we got to know the information from PTT Exploration and Production Public Company Limited (PTTEP) and Naresuan University.We want biogas to help bad smell from animal dungs. And reduce the cost of the village. We used gas from biogas for cooking and use waste to make fertilizer. Take the fermented water from the gas digester to inject banana tree. No need for chemicals,sesulting in good soil, including vegetable plots, fish pond demonstrations, and the use of technology for village development.

Mr. Kamon Chandang community member and the owner of a large pig farm said "Community members are more alert. Biogas helps reduce household expenses and improving the environment in the community without bad smell from animal drugs. And the relationship between the neighbors got better."

6 CONCLUSIONS AND DISSCUSSION

Ban Nong Ma Kor Community, Nong Luang Subdistrict, Lan Krabue District Kamphaeng Phet Province There is a 40 cubic meter biogas system in a community and a gas pipeline is sent to another 10 households, total 11 households to solve community problems. And also expanding the pelletizing machine for fish and frogs, as well as an earthworm farming system to produce manure and fertilizer, as well as a demonstration vegetable plot. There is also a water system commanding system by measuring humidity, temperature, acidity. Bringing digital technology to help develop, upgrade the management of renewable energy can solve community problems.

In accordance with the concept “Sustainability Development” include 3 dimension economy, society and environment. Society requires access to resources and opportunities for people in society to have equality, human rights and other benefits. Environment is sustainable use of resources. The preservation of natural capital by the world's ecosystems will not be affected. And economy must grow to create an appropriate income Reduce poverty And increase fair distribution of income. (Anantachai Yoonpratom et al,2014)

1. Dimensions Economic can help reduce the cost of purchasing LPG gas and fertilizer for use in agriculture. And increase revenue from selling organic vegetables Earthworm water and also have the opportunity to increase income by allowing those interested in studying to be a Bio Smart Farming Management for community Model in order to further expand the community development.

2. Social Dimensions improve the relationships of people in the community. Community members have cooperation. And have unity in both the practice and the mind.

3. Environment Dimensions there make the community a better environment free from bad smell from livestock farming. That is causing the bad smell in the community.

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Financial Analysis of Urban Bamboo-Ponics Vertical Farm

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Abstract: Model of urban vertical farming is invented by Professor Dickson Despommier from Columbia University to meet the needs of food production for feed the growing population in the future and to solve the water and energy crisis in the United States. Bamboo-ponics come from bamboo pipes combine with aeroponics technique. Bamboo-ponics vertical farm in this study consists of bamboo pipes 16 units with 12 holes around bamboo pipes, can grow 192 plants. The system high 220 centimeter with area 0.86 square meter. This study uses lettuces as a model crops because lettuces is short life vegetables can yield in 45 days and can continue grow immediately with 15 days for gemination. The aim of this case study was (1) analyzing financial for determine cost and benefit for startup Bamboo-ponics vertical farm and (2) identify income per square meter for use it to be sustainable house in the future. Bamboo-Ponics vertical farming has startup cost 20,000 Baht including bamboo pipes cost, structure cost, system cost, selling cost, electrical bill, seeds, and fertilizers in 1st year after that an owner pay only selling cost, electrical bill, seeds, and fertilizers. Lifetime of the system is 4 years. Market price of hydroponics lettuces are 125 Baht per kilogram and weight of lettuce per unit is 0.095 kilogram. In 1st year the owner can harvest 11 times owing to lose time for nursing crops 15 days from 365 days before growing in bamboo pipes. In 2nd year the owner can harvest 12 times 3rd can harvest 13 times and 4th year 12 times. Net profit in 4 years of growing lettuces in Bamboo-Ponics vertical farm is 23,230 Baht. Net income per square meter of Bamboo-Ponics vertical farm is 27,012 Baht per square meter.

Keywords: Urban Farm, Vertical Farm, Bamboo-Ponics, Financial analysis

1 INTRODUCTION

In 2050 the number of people living on the earth will approach to10 billion and more 2.5 billion people will live in urban areas (Held, 2017. and Lardieri, 2018). The predication of Worldometers is Thai population will increase to a maximum of nearly 70 million people (Worldometers, 2019) and according to National Statistical Office reports in October-December 2019 show that there are 569,000 people moving to urban area for more comfortable in their life (National Statistical Office, 2019). The advancement in science and technology of the world helping Thailand more comfortable by fast and modern transportation but Thailand has limited space and the land is expensive. Most urban people in Thailand will live in high-rise buildings such as flats or condominiums and residences have a limited space so, growing vegetable by using soil it is difficult (Thuekhaw, 2017). Urban farming and vertical farming are one of the concepts that have arisen. Model of urban vertical farming is invented by Professor Dickson Despommier from Columbia University to meet the needs of food production for feed the growing population in the future and to solve the water and energy crisis in the United States. Urban Vertical farming has received a lot of attention to research and experimentation to solve various problems as food safety, pollution problem and climate change affecting agricultural areas including hydrology. Urban vertical farming can be carried out throughout the year because use limited space, save energy and yielding higher than conventional agriculture when compared to similar areas of agriculture. (Saowanee, 2018)

The aim of this case study is (1) analyzing financial for determine cost and benefit for startup Bamboo-ponics vertical farm and (2) identify income per square meter for sustainable house in the future. Financial analysis in this case study is initiated from School of Renewable Energy and Smart Grid Technology at Naresuan University, Thailand by Research and Development. “The Bamboo-Ponics Vertical farm” which has used less plastic for doing urban vertical agricultural by use bamboo pipe instead of plastic pipes and use aeroponic technique for growing lettuces inside bamboo pipe.

2 BAMBOO-PONICS SYSTEM

Bamboo-ponics come from bamboo combine with aeroponics. Aeroponic come from Latin language by aero mean air and ponic mean cultivation so, aeroponics definition is growing plant by the root is in the air which has a container holding the plant for make the roots are suspended in the air (Kasetorganic, 2017). Bamboo-ponics vertical farm in this study is make bamboos to pipe and hole around bamboos, hang the bamboos around the sun shine house side and growing plants in there, feed plants by water with liquid fertilizer directly to roots inside bamboos by mist of solution then harvest and sell after fully grown.

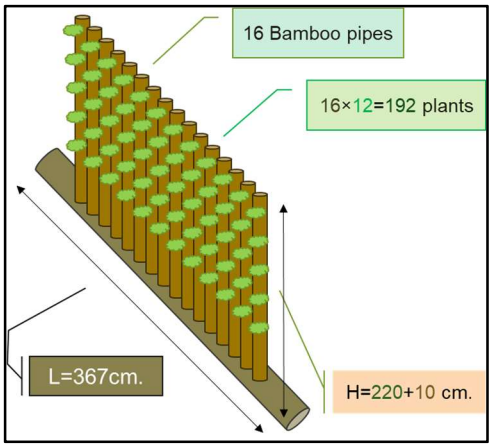

Figure 1: Bamboo-Ponics system structure.

Figure 1: Those bamboos and plants will turn into house insulator and filter for reduce heat and direct radiation from the sun. Bamboo-ponics system consists of bamboo pipes 16 units with 12 holes around bamboo pipes can grow 192 plants. The system high 220 centimeter and area 0.86 square meter. This study uses lettuces (green oak, red oak, and green cos) as a model crops because lettuces is short life vegetables can yield in 45 days and can continue grow immediately with 15 days for gemination. Lettuces are appropriate for growing in Bamboo-ponics vertical farm forasmuch size of bush around 29-34 centimeter and high around 14-26 centimeter (Atthasit Chuenjai and Chumnan Boonyaphutthipong, 2017). Market price of lettuces from Talaad Thai, Bangkok show that 80-85 Baht per kilogram (Talaad Thai, 2020) and market price of lettuces in Hydroponics farm at Phitsanulok from interviewed is average 125 Baht per kilogram (Yodthong, 2019., Banfarmpuk, 2019., Moderngreen farm, 2019., and Wes farm, 2019).

3 FINANCIAL STATEMENT

3.1 Income statement

Income statement of this system uses for measuring the profitability of a system in 1st - 4th year, it can investigate the profit or loss after deducting all of expenses (Block and Hirt, 2008). From this system get gross profit from sale deducting cost of goods sold (labor cost + seed cost + fertilizer cost). The operating expense, selling expenses and depreciation are deducted from gross profit representing operation profit.

Table 1: Income statement of 1st and 2nd year.

Bamboo-ponics system Income Statement Ending of year 31st December		
Revenue	2020	2021
Sale	฿ 25,080.00	฿ 27,360.00
Cost of goods sold	-฿ 10,969.76	-฿ 10,878.24
Gross profit	฿ 14,110.24	฿ 16,481.76
Expenses		
Depreciation expenses	-฿ 3,436.56	-฿ 3,436.56
Operating expenses	-฿ 1,058.40	-฿ 1,103.76
Selling expenses	-฿ 5,632.00	-฿ 6,144.00
Operating profit (EBIT)	฿ 3,983.28	฿ 5,797.44
Interest expenses	฿ -	฿ -
EBT	฿ 3,983.28	฿ 5,797.44
Taxes	฿ -	฿ -
EAT	฿ 3,983.28	฿ 5,797.44

The system does not has to pay tax because income before interest and tax in each year below 150,000 per year.

Table 2: Income statement of 3rd and 4th year.

Bamboo-ponics system Income Statement Ending of year 31st December		
Revenue	2022	2023
Sale	฿ 29,640.00	฿ 27,360.00
Cost of goods sold	-฿12,758.24	-฿ 8,926.72
Gross profit	฿ 16,881.76	฿ 18,433.28
Expenses		
Depreciation expenses	-฿ 3,436.56	-฿ 3,436.56
Operating expenses	-฿ 1,103.76	-฿ 1,088.64
Selling expenses	-฿ 6,656.00	-฿ 6,144.00
Operating profit (EBIT)	฿ 5,685.44	฿ 7,764.08
Interest expenses	฿ -	฿ -
EBT	฿ 5,685.44	฿ 7,764.08
Taxes	฿ -	฿ -
EAT	฿ 5,685.44	฿ 7,764.08

Table 1 and Table 2: Bamboo-Ponics system income statement indicate in 3rd year earned the most sale because of 13 times harvesting and in 1st year earning the least sale because of lettuces are harvested only 11 times. In 2023 (4th year) show that cost of goods sold less than other year and net income more than other year owing to in 3rd year must buy seeds and fertilizers for 4th year in advance thus, when cost of goods sold decrease make net income increase. Net income of 1st year less than other year because in this year can harvested the least. Net income from income statement in table 1 and 2 show that in 4 years Bamboo-Ponics system will receive income 23,230.24 Baht.

3.2 Balance sheet

In forward to providing overview in 1st to 4th year of a Bamboo-Ponics system's financial condition, the balance sheet discloses the inside workings of this system's financial structure.

Balance sheet of this system consist of asset and owner's equity and without liabilities. This case study uses owner fund case instead of loan. Assets define to current asset as cash and fixed asset as plants, equipment cost and accumulated depreciation. Owner's equity refers to owner investment and retained earnings.

Table 3: Balance sheet of 1st and 2nd year.

Bamboo-ponics system Date:	Balance Sheet 31st, December	
Assets	2020	2021
Current Assets		
Cash	13,674	22,908
Accounts receivable	-	-
Inventory	-	-
Prepaid expenses	-	-
Short-term investments	-	-
Total current assets	13,674	22,908
Fixed (Long-Term) Assets		
Long-term investments	-	-
Property, plant, and equipment	13,746	13,746
(Less accumulated depreciation)	(3,437)	(6,873)
Intangible assets	-	-
Total fixed assets	10,310	6,873
Total Assets	23,984	29,781
Liabilities and Owner's Equity		
Owner's Equity		
Owner's investment	20,000	20,000
Retained earnings	3,983	9,781
Other		
Total owner's equity	23,983	29,781
Total Liabilities and Owner's Equity	23,983	29,781

Table 3: Balance sheet of Bamboo-Ponics system show that owner's investment is 20,000 Baht. Total assets in 1st year were 23,983.66 Baht refers to 13,673.90 Baht in current asset and fixed asset is 10,309.76 Baht. Retained earnings is 3,983.28 Baht. In 2nd year fixed asset is 6,872.83 Baht and current asset is 22,907.90 Baht then, total assets are 29,780.73 Baht. Retained earnings is 9780.72 Baht.

Table 4: Total assets in 3rd year show 35,466 Baht refers to current asset 32,030 Baht and 3,436 Baht in fixed asset. Retained earnings is 15,466 Baht. In 4th year total assets are 43,230 Baht for current asset is 43,231 Baht and fixed asset in this year equal zero because depreciation in this system is fixed depreciation. Retained earnings is 23,230 Baht.

Table 3 and Table 4: Current assets rapidly high because sales increase rapidly but total fixed assets do not change so, cash from sales in each year can use for investment in other way to use assets for produce income more worthily.

Table 4: Balance sheet of 3rd and 4th year.

Bamboo-ponics system Date:	Balance Sheet 31st, December	
Assets	**2022**	**2023**
Current Assets		
Cash	32,030	43,231
Accounts receivable	-	-
Inventory	-	-
Prepaid expenses	-	-
Short-term investments	-	-
Total current assets	32,030	43,231
Fixed (Long-Term) Assets		
Long-term investments	-	-
Property, plant, and equipment	13,746	13,746
(Less accumulated depreciation)	(10,310)	(13,746)
Intangible assets	-	-
Total fixed assets	3,436	(0)
Total Assets	35,466	43,230
Liabilities and Owner's Equity		
Owner's Equity		
Owner's investment	20,000	20,000
Retained earnings	15,466	23,230
Other		
Total owner's equity	35,466	43,230
Total Liabilities and Owner's Equity	35,466	43,230

3.3 A statement of cash flow

Statement of cash flow refers to cash inflow's Bamboo-Ponics system during 1st to 4th year. This case study uses owner fund then, a statement of cash flow can define in 2 types as operating activities and investing activities without financing activities. The main solution for constructing a statements of cash flow starts by use net income from income statement and then, add noncash deduction as depreciation to arrive at net cash provided by operating activities for investing activities use plant and equipment cost from balance sheet (Melicher and Norton, 2000).

Table 5: Net cash provided by operating activities in 1st year to 4th year are 7,419.84 Baht, 9,234.00 Baht, 9,122.00 Baht and 11,200.64 Baht in respectively. Net cash uses in investing activities has only in 1st year because this system is a one-time investment. Net decrease in cash and marketable securities of 1st year is -6,326.40 Baht because net income does not reach breakeven point. Net increase in cash and marketable securities of 2nd to 4th year are 9,234 Baht, 9,122 Baht and 11,200.64 Baht respectively.

In statement of cashflow depreciation cost cannot count to cash out flow then, according to table 5 show that after 1st year this system run by without cash outflow it means this system has more liquidity of cash owing to inflow of this system more than cash outflow.

Table 5: Cash flow statement.

Bamboo-Ponics System	
Statement of Cash Flows	
Ending year 31st, 2020	
Cash Flows from Operating Activities	
Net income	฿ 3,983.28
Depreciation	฿ 3,436.56
Net cash provided by operating activities	**฿ 7,419.84**
Cash Flows from investing activities	
Increase in plant and equipment	-฿ 13,746.24
Net cash used in investing activities	**-฿ 13,746.24**
Net increase/decrease in cash and marketable securities	**-฿ 6,326.40**
Ending year 31st, 2021	
Cash Flows from Operating Activities	
Net income	฿ 5,797.44
Depreciation	฿ 3,436.56
Net cash provided by operating activities	**฿ 9,234.00**
Cash Flows from investing activities	
Increase in plant and equipment	฿ -
Net cash used in investing activities	฿ -
Net increase/decrease in cash and marketable securities	**฿ 9,234.00**
Ending year 31st, 2022	
Cash Flows from Operating Activities	
Net income	฿ 5,685.44
Depreciation	฿ 3,436.56
Net cash provided by operating activities	**฿ 9,122.00**
Cash Flows from investing activities	
Increase in plant and equipment	฿ -
Net cash used in investing activities	฿ -
Net increase/decrease in cash and marketable securities	**฿ 9,122.00**
Ending year 31st, 2023	
Cash Flows from Operating Activities	
Net income	฿ 7,764.08
Depreciation	฿ 3,436.56
Net cash provided by operating activities	**฿ 11,200.64**
Cash Flows from investing activities	
Increase in plant and equipment	฿ -
Net cash used in investing activities	฿ -
Net increase/decrease in cash and marketable securities	**฿ 11,200.64**

3.4 Breakeven Point analysis

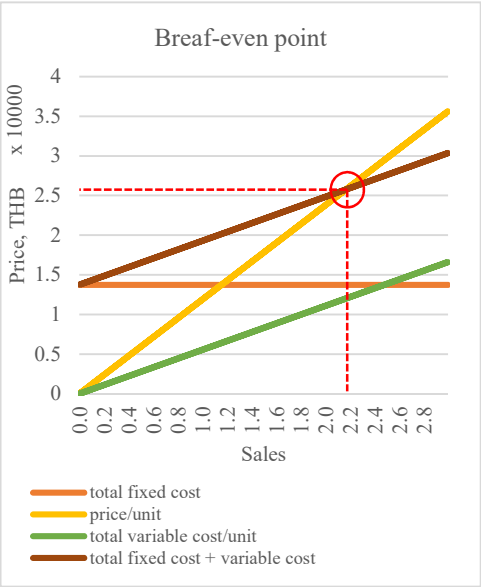

Figure 2: Break-even point.

Break-even point is the quantity of sales that will make the selling price equal to the total cost incurred from production and selling product (Melicher and Norton, 2000). Sales according to sales volume at breakeven point will not make company get profit or loss. Therefore, calculating break-even points will know how much sales volumes are needed to make a profit. Calculate BEP (Unit) in this system will know how much unit are needed to sell for have a zero profit.

Figure 2: Sell quantities for get zero profit of this system is 2,168.19 units with 25,758.10 THB, equal to 11.29 times of harvested for protect loss so, this system gets zero profit in 1st harvesting of 2nd year referring to the system can start to payback in beginning of 2nd year and owner can withdraw capital in end of 2nd year.

4 FINANCIAL STATEMENT ANALYSIS AND DISCUSSION

Financial statement shows operation's result of Bamboo-Ponics system's financial position at 1st to 4th year. Financial statement analysis indicates effect of nonfinancial operations of this system as asset management ratios and profitability ratios.

4.1 Asset management ratios

Asset management ratios report about assets using to support sales. This ratio uses information by income statement and balance sheet from table 1 and 2. Categories of this ratios are total assets turnover ratio and fixed assets turnover ratios. Calculation of assets turnover ratios is net sale divide by total asset of Bamboo-Ponics system (Melicher and Norton, 2000).

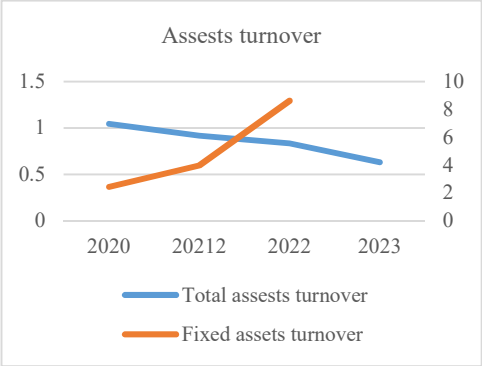

Figure 3: Assests turnover ratio.

Figure 2: Show total assets turnover is 1.05 times in 1st year, 0.92 times in 2nd year, 0.84 times in 3rd year, and 0.063 times in 4th year. Fixed assets turnover ratio indicates how much is it worth of Bamboo-Ponics system using fixed assets to produce sales. Computed by net sales divide by fixed assets. 1st year to 3rd year are 2.43 times, 3.98 times, and 8.63 times respectively Bamboo-Ponics system increases of fixed assets turnover it is referring to this system uses fixed assets to produce sales worthily. In 4th years fixed assets turnover is very high cause of not have fixed assets from system expiring.

Assets turnover ratio and total fixed assets turnover indicate ability to use total asset (Melicher and Norton, 2000), assets turnover decrease owing to total assets increasing than sales in every year. But when compare with increasing of fixed assets turnover that means decreasing in total asset turnover come from cash received by selling goods add into current asset. Then fixed asset turnover continually increase owing to this system is one-time investment and lifetime value is 4th year so, in ending of 4th year system will depreciate, and total fixed assets turnover has only net sales.

4.2 Profitability ratios

Profitability ratio refer to ability of generate return on sales, assets and equity of Bamboo-Ponics system. Categories of this ratio are operating profit margin, net profit margin, operating return on assets, return on total assets, and return on equity. Operating profit margin use for measure ability to control operating expenses of this system compare to sales, computing by earnings before interest and tax (EBIT) divide by net sale. (Melicher and Norton, 2000).

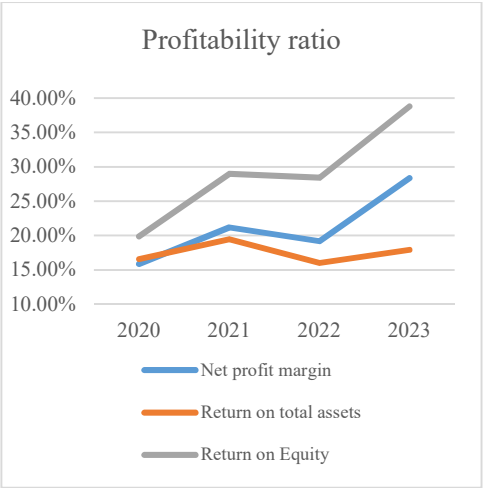

Figure 4: Profitability ratio.

Net profit margin use for measure profitability of Bamboo-Ponics system by including tax and interest expenses, computed by income after tax divided by net sales (Melicher and Norton, 2000). Both ratios will show the same results owing to net income equal to EBIT because this system no need to pay tax.

Figure 4: The net profit margin of this system is 15.88%, 21.19%, 19.18% and 28.38% respectively. Bamboo-Ponics system was able to improvement its operating profit. In 3rd year operating profit margin declined slightly from 2nd year because cost of goods sold more than other year. Net profit margin indicated that profitability improving in every year. It refers to this system has ability to earn a return.

Operating return on assets is use for identifying the performance of business operations and the profitability generated from assets used (Melicher and Norton, 2000). This ratio not including to tax or interest. Calculating of this ratio is EBIT divide by total asset. Return on total assets used to measure return on investment in asset after deducted operating expenses and tax obligation, computed by net

income divide by total asset (Melicher and Norton, 2000). Both ratios will show the same results owing to net income equal to EBIT because this system no need to pay tax. Return on total assets of this system is 16.6%, 19.47%, 16.03%, and 17.96% respectively. Return on total assets in 2nd year is the most because high income from 12 harvesting and only 1 deducting time of depreciation and the least is in 3rd year owing to seeds and fertilizers purchasing cost at the end of year in the same way, 4th year return on assets is high owing to no seeds and fertilizers cost.

Return on equity used for measuring the return to owner's investment (Melicher and Norton, 2000). Assets in this system does not have debt because owner invest by themselves not loan. Computed by net income divided by common equity (owner investment). From figure 3 indicate that return on equity of this system is 19.92% in 1st year, 28.99% in 2nd year, 28.43% in 3rd year, and 38.82% in 4th year, the results trend to increases in every year shows that this system can provide a high return on equity. owner has opportunity to receive high returns up to 38.82%.

5 CONCLUSION

Urban Bamboo-Ponics vertical farming helps urban people in Thailand who live in urban residences with limited space can grow vegetable by do not using soil. Bamboo-Ponics vertical farming has startup cost 20,000 Baht including bamboo pipes cost, structure cost, system cost, selling cost, electrical bill, seeds, and fertilizers in 1st year after that an owner pay only selling cost, electrical bill, seeds, and fertilizers. Lifetime of the system is 4 years. Lettuces is short life plant can harvest in 45 days. Market price of hydroponics lettuces are 125 Baht per kilogram and weight of lettuce per unit is 0.095 kilogram. In 1st year the owner can harvest 11 times owing to lose time for nursing crops 15 days from 365 days before growing in bamboo pipes. In 2nd year the owner can harvest 12 times 3rd can harvest 13 times and 4th year 12 times. Net profit in 4 years of growing lettuces in Bamboo-Ponics vertical farm is 23,230 Baht. Net income per square meter of Bamboo-Ponics vertical farm is 27,012 Baht per square meter. Comparing to conventional farming income is 4,533.12 Baht per square meter (Kayakiri, 2019) Bamboo-Ponics vertical farm gets income per square meter more than conventional farming 5.96 times.

SUGGESTION

From the results of study show the interesting probability to get a side income for doing sustainable house by Bamboo-ponics vertical farming however, Bamboo-ponics system should be studied in term of practical planting in future for make sure the production is same as assumption or less/more than assumption.

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The Comparison of Energy Management Criteria for Energy Efficiency Development in the School

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Abstract: Presently, global electricity consumption has been consistently increasing. Many countries around the world are raising awareness and contributing to energy saving and electricity consumption. The responsibility lies mostly with the government, industrial, and education sectors. The governments are required to implement both mandatory and supportive strategic approaches in order to solve the global energy problems. In response to the government policy of energy saving solutions, this article is dedicated to review energy management criteria and develop guidelines for energy efficiency development in the schools. The concepts and principles of ISO 50001's requirements for energy management standards, the awards judging criteria of Thailand Energy Awards and Energy Mind Awards, as well as other related energy efficiency standards were analyzed. It was found that ISO 50001 provided a comprehensive framework of requirements in PDCA cycle to help the organizations achieve continual improvement of energy performance. Additionally, the criteria for Thailand Energy Awards and Energy Mind Awards were appropriate for the schools to follow and improve their energy efficiency. As a result, the article proposed a practical guideline for promoting school energy efficiency in PDCA cycle. The planning (P) criteria is an essential part for establishing school rules and regulations, allocating resources and responsibilities, as well as conducting performance evaluation. The doing (D) criteria is the policy implementation process to improve the energy performance of the schools. The criteria for doing (D) includes communication and public relations, training, procurement, project implementation, energy activities and participation both within and outside of the schools. The checking (C) criteria is an important criterion for evaluating and following up in achieving objectives of the projects and activities. Lastly, the acting (A) criteria is a participation criterion for the performance improvement between management, practitioners and the community in order to ensure effective results.

Keywords: Energy Management, Energy Criteria and Indicators, School Energy Management, Energy Efficiency

1 INTRODUCTION

Energy crisis has been a global issue for the last few decades. Energy demand is increasing as economic growth, while the limited natural resources are diminishing steadily. The energy crisis would thus have a dramatic impact on the global population and economy. Additionally, the energy crisis is closely linked to the environmental crisis. Global carbon emissions from fossil fuels have significantly increased as a result of higher energy consumption. In order to solve the energy crisis and reduce global warming, the Thai Government passed the Energy Conservation Promotion Act 1992 to supervise, promote, and support the designated factory and designated building to conserve energy. (Energy Conservation Promotion Act, 1992). The act also focuses on supporting effective use of energy to maximize benefits, as well as raising awareness of employees by promoting an energy management system.

The building sector is seen as the biggest single contributor to world energy consumption and greenhouse gas emissions. Energy consumption in buildings has been accounted up to 40% of the total world (Salleh, M., kandar, M. & Sakip, S., 2016). Since non-residential buildings, such as school buildings, represent a significant part and consume more energy than residential buildings, the education sector should therefore be responsible for energy use as well. In Thailand, some of the schools have focused on achieving energy savings in buildings by implementing in the energy conservation projects, using energy efficient equipment, raising awareness of energy conservation to the staff and students, and integrating energy conservation content with education. However, most schools lack of energy efficient inspection, energy monitoring and evaluation, as well as continuous improvement in energy efficiency for the sustainable conservation.

Many various studies have demonstrated that energy management system plays a crucial role in sustainable energy conservation. Since schools are seen as a key priority for a sustainable energy training and awareness, they should have guidelines as proper direction for implementing energy management systems. The guidelines for schools energy efficiency should present criteria and indicators that are simple but practical, effective, easy to verify, and be able to evaluate for effective energy management. This research is thus review ISO 50001 standard, criteria for the Thailand energy awards, and other related studies for energy efficiency and energy effectiveness in the schools. The energy criteria and indicators will then develop for successful implementation and improvement of energy management system.

2 OBJECTIVE

To review and develop practical guideline of energy management and energy conservation for the schools.

3 METHODOLOGY

This article used a documentary research method as a tool to develop criteria and indicators of energy management for the schools. In doing so, the laws related to energy management in Thailand, energy policy, energy conservation policy, ISO 50001 energy management system, behaviour change for energy efficiency, energy awards judging criteria, as well as other related studies for energy efficiency were analyzed. Understanding the requirements of energy management system and the criteria to energy efficiency, the schools would be enable to take a systematic approach in order to achieve continual improvement of energy performance, such as energy efficiency, energy use and consumption.

4 RESULTS

The criteria and indicators have been established by the documentary analysis of related studies for energy efficiency. The systematic process of PDCA (Plan, Do, Check, and Act) cycle in energy management is suggested as a useful guideline in achieving continuous improvement of energy efficiency in the schools. Table 1 shows the comparison and suggestion of criteria in P process between ISO 50001 energy management system, energy awards juding criteria for Thailand Energy Awards and Energy Mind Awards, and other related studies for energy efficiency. It was found that ISO 50001 had the most comprehensive criteria. Most of the planning criteria were considered important, especially responsibilities of the top management, energy statistics database, as well as plans, objectives, and goals setting. Therefore, it was suggested that school leaders need to set goals for energy efficiency and energy conservation. They also need to set up the energy statistics database for effective energy planning, and lead energy policies into practice.

Table 1: Comparison and Suggestion of the Planning (P) Criteria.

Planning Criteria	ISO 50001	Energy Awards Judging Criteria	Other Related Studies of EE
- Preliminary assessment	✓	N/A	N/A
- Responsibilities of the top management	✓	✓	✓
- Policy	✓	N/A	✓
- Legal and other regulations	✓	N/A	N/A
- Energy review	✓	N/A	N/A
- Energy statistics database, such as energy consumption data and building energy consumption	✓	✓	✓
- Performance indicators	✓	N/A	N/A
- Plans, objectives, and goals setting	✓	✓	✓
- academic and technology support	N/A	✓	N/A

The comparison and suggestion of the doing (D) criteria in Table 2 showed that all standards (including ISO 50001, energy awards judging criteria, and other related studies of energy efficiency) had different directions. The ISO 50001 had identified many requirements and specifications to manage energy performance in the organizations. The doing criteria was a necessary approach to implementation, therefore, the suggested criteria for school leaders include effective communication to the staff and student, support energy efficiency projects and activity engagement, as well as enhance learning ability and energy awareness for a sustainable development.

Table 2: Comparison and Suggestion of the Doing (D) Criteria.

Doing Criteria	ISO 50001	Energy Awards Judging Criteria	Other Related Studies of EE
- Learning ability and energy awareness	✓	✓	N/A
- Communication	✓	✓	N/A
- Document management system	✓	N/A	N/A
- Operational Control	✓	N/A	N/A
- Design	✓	N/A	N/A
- Procurement	✓	N/A	✓
- Implementation	✓	N/A	N/A
- Supportion of activity engagement inside and outside of the school	N/A	✓	✓
- Project extension and expansion outside of the school	N/A	N/A	✓

Table 3: Comparison and Suggestion of the Checking (C) Criteria.

Checking Criteria	ISO 50001	Energy Awards Judging Criteria	Other Related Studies of EE
- Monitoring, measurement, and analysis	✓	N/A	N/A
- Legal and regulatory compliance	✓	N/A	N/A
- Internal Audit	✓	N/A	N/A
- Corrective and Preventive Actions, nonconformity	✓	N/A	N/A
- Evaluation of key performance indicators	N/A	N/A	✓

Table 3 shows the comparison and suggestion of the checking criteria. This criteria is considered as an important step in checking the effectiveness of implementation strategies for energy efficiency. It was found that ISO 50001 provided a process for monitoring to ensure the efficiency of the organization's energy management system. Additionally, suggestion criteria for the C process include monitoring, measurement, analysis, and evaluation from the internal audit. Corrective and preventive actions

must be taken to eliminate the cause of a potential nonconformity or other potential undesirable situation.

Table 4: Comparison and Suggestion of the Acting (A) Criteria.

Acting Criteria	ISO 50001	Energy Awards Judging Criteria	Other Related Studies of EE
- Management Review	✓	N/A	N/A

The comparison and suggestion of the acting (A) criteria in Table 4 showed that the acting process was concerned by ISO 50001 when comparing to the other requirement standards to enhane energy efficiency in the schools. School leaders need to periodically review the quality management system in order to ensure the ongoing effectiveness, address the needs for changes, and optimize the process for further development in order to achieve sustainable practices.

The comparison of energy management criteria for energy efficiency development have shown that ISO 50001 energy management systems standard includes systematically and detailed requirements to achieve continual improvement of the organization's energy performance than other criteria designed for energy efficiency in the schools. The criteria for managing school energy systems should be clear, therefore, this article proposed a PDCA cycle to improve sustainability performance in energy efficiency and energy conservation.

5 CONCLUSIONS

Schools are essential to manage energy use and promote learning to improve students' attitudes and energy conservation behavior. Since education is an effective way to encourage energy conservation in a long run, schools need a clear criteria and guideline to help them make informed decisions to make the greatest improvements in energy efficiency. The PDCA process brings continuity to energy management in accordance with ISO 50001. Consequently, the energy management system for the schools should adopt a PDCA approach for a continuous improvement. Step 1 (Plan) involved the responsibilities of top management to establish an energy policy and action plans for improving energy performance in the school. Step 2 (Do) was about promoting communication, awareness and support before the implementation of the action plan to ensure competence and consider energy performance in design and procurement. Step 3 (Check) included monitoring, analyzing, evaluating KPIs, as well as auditing and conducting management review of energy performance and energy management system. Step 4 (Act) was about the management review to take actions and address nonconformities in order to improve energy performance and energy management system.

The standards and criteria for energy management have been used in various sectors. For example, the ISO 50001 standard is widely used in the industrial sectors in order to improve operational and use energy more efficiently. At present, the schools are lack of a strategic approach and comprehensive criteria for energy saving and conservation. There are only energy awards judging criteria, such as Thailand Energy Awards and Energy Mind Awards, which focused on a documentary report than the school energy efficiency implementation. Accordingly, the development of criteria and guideline would make it easier for the schools to integrate energy management into their overall efforts to improve energy efficiency and save the environment.

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Investigation of Turbidity and TSS Removal from Leachate Landfill Via Electrocoagulation Process

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Abstract: This paper presents the ability of electrocoagulation process in decreasing of turbidity and total suspended solid (TSS) constituted from leachate landfill by using aluminium and stainless steel electrode. The landfill leachate used in the experiments was obtained from solid waste management centre in Melaka, Malaysia. The EC tests were performed in a bench-scale batch reactor with dimension (10 cm x 2 cm x 1 cm). The electrode was constructed with four combination from aluminium-aluminium, aluminium-stainless steel, stainless steel-stainless steel and stainless steel-aluminium. The voltage input varied at 2, 4, 6, 8 and 10 volt with constant reaction (10 minutes). Result showed that removal of turbidity and total suspended solid from leachate landfill increased due to the increasing of voltage input. The highest turbidity and total suspended solid removal electrodes combination show the greater turbidity removal at 6 volt with 90.7% for turbidity removal and 100% for total suspended solid removal. For others electrode combination such as aluminium-stainless steel, stainless steel-stainless steel and stainless steel-aluminium the highest turbidity removal are only 82.48%, 74.46% and 74.71%. This study indicated that the efficiency removal of all parameters increased as the voltage from 2 V to 6 V, but removal stagnant with an increase voltage. Also, removal efficiency was more in neutral pH. Finally, electrocoagulation process with aluminium-aluminium electrode is the best electrodes combination for treatment of leachate landfill.

Keywords: Electrocoagulation, Leachate Landfill, Electrodes, Turbidity, Total Suspended Solid

1 INTRODUCTION

One of the major issues that humanity faces in the twenty-first century is the need to provide water for the growing world population. The increasing of human population day by day gives a shock matter due to the corresponding improvement in the total quantity of industrial and municipal solid waste. The constituents in wastewater can be divided into two which are wastewater from society, while the other one is wastewater generated internally in treatment plants [1]. Leachate can be categorized a liquid waste. Leachate can be categorized a liquid waste inheriting high chemical oxygen demand (COD), high biochemical oxygen demand (BOD), high levels of colloidal particles and total suspended solid (TSS) as well as elevated values of total dissolved solid (TDS). The properties and ingredients of leachate landfill are well known to be very complex and contain tremendous of chemical contaminants, therefore appropriate treatment should be applied in treating the leachate landill [2].

There have been numerous approaches in attempts to handle landfill leachate due to its potential hazards to the environment. Amongst these, the focus highlight leachate transfer, biodegradation, chemical and physical methods as well as membrane processes as the main categories in leachate handling [3]. To date, chemical precipitation, magnetic field separation, adsorption, chemical oxidation, electrochemical oxidation, coagulation-flocculation and electrocoagulation (EC) have been namely investigated. Compared to current treatment processes available today, electrocoagulation can benefit from equipment simplicity; potable, clear, colorless and odorless treated product [4]. The physiochemical phenomena that occured in electrocoagulation are the oxidation and reduction process at anode and cathode electrode, the production and movements of flocculating agents in the aqueous phase, coagulation and adsorption of pollutants on flocculating agent and

electroflotation or sedimentation of coagulated accumulated [5].

Even though electrocoagulation is being dispute for the cost of the electrodes used for the process or the electricity cost itself, but it was covered by lots of advantages offer by the process such as stated by Karichappan et al. (2014) which are robustness to varying reaction conditions and effluent types, ease of operation, shorter retention time, quick sedimentation of the electrogenerated flocculants, lower production of sludge and smaller space requirements [6].

In spite of effectiveness elecrocoagulation process has been proven for wastewater treatment such as textile industry, sewage and palm oil effluent. In this study the electrocoagulation process is conduct to treat leachate landfill by removal of turbidity and total suspended solid (TSS) with changes of electrode combination such as Al - Al , Steel-Al, Al - Steel and Steel-Steel. This article investigates the application of electrocoagulation in the treatment of a real sample of landfill leachate. The experiments will be carried out in a batch mode in order to evaluate the effects of different operational variables including voltage and electrode combination and their effects on the removal of turbidity and total suspended solid from leachate landfill.

2 METHOD AND MATERIALS

2.1 Experimental Procedure

The sample was collected from one of the solid waste management centre in Malaysia. The sample stored in glass bottles for 10 L transporting in ice cool container to the lab and store at 4ºC in order to keep the sample characteristic unchange. To investigate the raw leachate properties, real leachate sample were analyzed to evaluate its initialis turbidity, total suspended solid (TSS) and pH. Next, the electrode is weighed, while 250 ml sample is prepare in a beaker and place on magnetic stirrer. The dimension of the electrode use is 10 cm × 2 cm × 1 cm, the electrode is cut by using shearing machine.

Figure 1.0 shows, experimental set up for electrocoagulation cell. The set up of electrochemical cell consist of two electrodes with 2 cm apart is stirred at 3 rpm. The voltage for power supply is varied at 2 V, 4 V, 6 V, 8 V and 10 V for different combinations of electrodes at constant time which is 10 minutes, then the electrode is weighed again after the experiment for each run. The samples are filtered after electocoagulation process before being analyse for post analysis to determine final turbidity, total suspended solid (TSS) and pH. All electrodes are washing with dilute 1% HCl before every experiment conducted. Every experiment was conducted at the room (~ 25°C) temperature. Table 1 shows, the initial turbidity, total suspended solid and pH for leachate landfill.

Table 1 Initial turbidity, total suspended solid and pH for leachate landfill

Parameter	Value
Turbidity (NTU)	80
Total Suspended Solid (mg/l)	202
pH	4.9

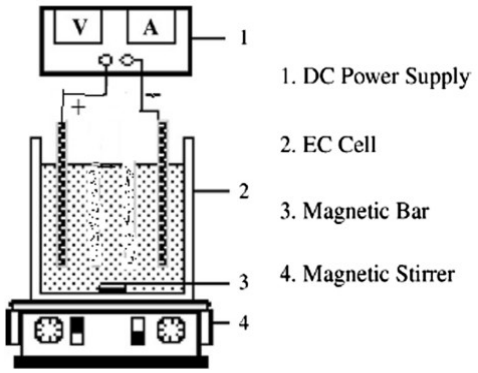

Figure 1.0 Experimental setup for electrocoagulation cell.

3 RESULT AND DISCUSSION

3.1 Turbidity Removal

The variations of the rate of turbidity removal at different voltage from 2 V to 10 V are shown in figure 2.0 and figure 3.0. The graph showed that for four combination electrodes, a significant increase of the turbidity removal efficiencies could be observed with the increment in applied voltage. According to Faraday's law, the amount of coagulant or dissolved anodic metal is theoretically and directly proportional to the applied current to an electrolytic cell at a certain time. Thus, increasing applied voltage (or current density) results in an increasing amount of aluminum hydroxide flocs for the removal of colloidal particles.

The maximum turbidity removal efficiency were recorded for Al-Al, Al-Steel, Steel-Al at 8V

with constant 10 min operation were 90%. This is due to, Al-Al combination is stable and known as reactive metal in the electrochemical series since it tends to oxidize better than the metals found at the bottom of the series which means that it can react more easily to flocculate the coagulant inside the wastewater [7]. Even though the removal percentage at Al-Al electrode combination has a bit decreasing value it still show the most constant removal percentage that in range of 80% to 90% removal compare to other electrode combination. Aluminium as anode produce corresponding metals ions that almost immediately hydrolyze so that, it form an excellent coagulating agent, beside that, aluminium is more reactive type of metal compare to ferum ions that generated from steel electrode [8].

Other than that, Al-Steel has the removal efficiency of 76.43% but then, the graph decreases with increasing voltage. This is due to the combination of aluminium electrode and steel electrode which is not really stable, therefore it might caused the removal efficiency to be lower than other combinations. Besides that, this was attributed to the in situ formation of dispersed aluminium–hydroxide complexes through hydrolysis of the aluminate ion, which does not occur when employing steel electrodes. The efficiencies perentage for four electrodes slightly reduce at voltage 10 V, might be due to electrode passivation. Electrode passivation refer to material becoming "passive," that is, less affected or corroded by the environment. The species that produced during the reaction accumulates at the surface of the electrode which eventually block the electrode surface and dramatically reduce the efficiency.

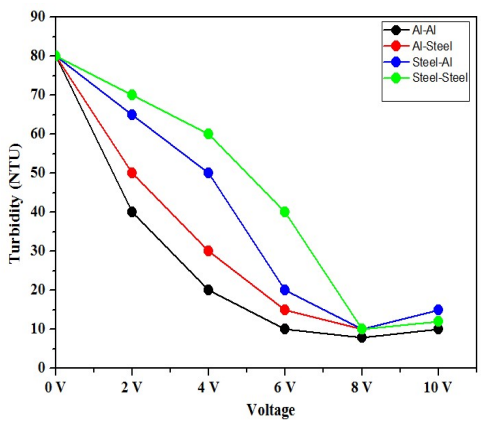

Figure 2.0 Effect of electrocoagulation voltage on turbidity removal.

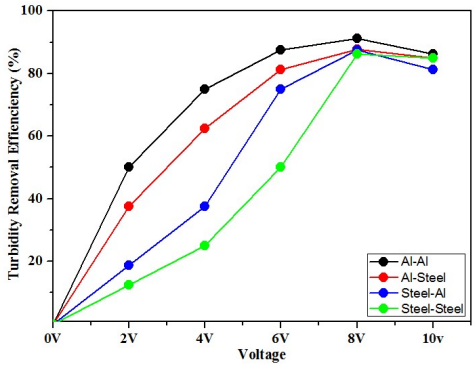

Figure 3.0 Percentage turbidity removal efficiency of electrocoagulation voltage on turbidity removal

3.2 Total Suspended Solid Removal

For four electrodes combination, the TSS removal efficiency and voltage range of electrocoagulation process is depicted in figure 4.0 and figure 5.0 in which maximum removal occured at 6 V dan beyond that no further significant increased was observed. Figure 4.0 also depicts that for four electrodes combination as the voltage increased from 2 V to 6 V. Removal efficiency of about 80% was achieved for Al-Al electrodes at the voltage of 6V and at constant time 10 min as shown in Figure 5.0. The steadiness of removal efficiency in leachate landfill at 6V to 10V corresponds to steadiness in the generation of bubbles observed during electrocoagulation of leachate landfill.

With Al-Al combination, the maximum removal of TSS (80 %) was observed using the voltage 6 V ,while with the use of Al-Steel, there was least removal of colour TSS (72.5%) using the voltage 6 V, steel-Al removal efficiency (67.5%) and steel-steel TSS removal efficiency (60%) with the operating conditions of 10 mins. In this experiment, it was found that the result for different electrodes shown different in removal efficiency achieved. It depends on the conductivity of the materials that has been used as electrodes. The Aluminium electrodes give a better result for removal of colour and turbidity instead stainless steel electrodes. This is due to sufficient voltage through the solution, the metal ions generated by the disolution of the sacrificial electrodes were hydrolyzed to form a series of metallic hydroxide species. These species neutralized the electrostatic charges on dispersed particles to reduce the electrostatic interparticle repulsion enough so that the Van der Waal's attraction predominates, thus facilitating agglomeration [9].

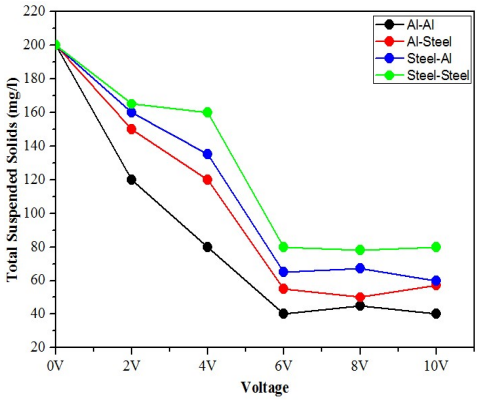

Figure 4.0 Effect of electrocoagulation voltage on turbidity removal.

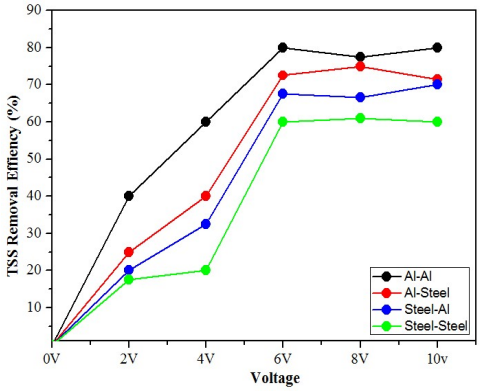

Figure 5.0 Percentage TSS removal efficiency

3.3 Effect of pH on Leachate

From the observation, when aluminium becomes the anode electrode such as Al-Al and Al-Fe, the graph has a trend of increasing in pH which are in the range of 7 to 8.5 from an initial pH of 4.94. The final pH mostly increases from the initial pH due to the OH- ions released during the hydrolysis of water at the cathode by electrochemical reaction [10]. The increasing in pH might be due to the production and consumption of hydroxyl ions during electrocoagulation process.

From Figure 6.0, it indicates that most of the pH falls under the values of 6 to 8.5, hence this method is suitable for the changes of pH since the permissible discharge for pH is in the range of 6 to 9. Therefore, electrocoagulation process stabilizes the final pH values where it tends to become neutral and further treatment by using chemical in order to reduce or increase the pH is not necessary anymore.

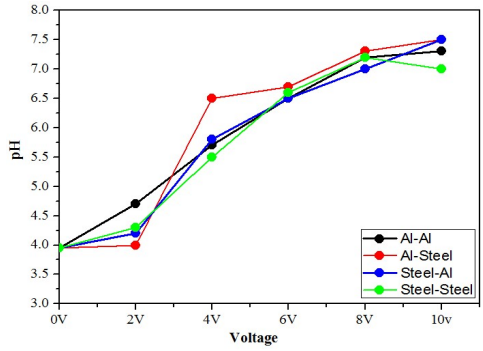

Figure 6.0 Effect of pH with voltage increment.

4 CONCLUSIONS

The use of all the combinations of electrodes (Al-Al, Al-Fe, Fe-Fe and Fe-Al) for the removal of turbidity and TSS of leachate landfill by electrocoagulation process were found to be dependent on the voltage. Among the different electrode combinations, Al-Al combination was found to be most effective in removing turbidity and TSS removal. The kinetic rate constants for colour, TD and TSS removal at various voltages indicated that pseudo firstorder kinetic was in good agreement with the significant correlation coefficients (>.90) of the experimental result

ACKNOWLEDGEMENTS

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Guidelines of Activity and Service Development to Promote the Well-Being among the Elderly People in Wang Thong Sub-district, Wang Nuea District, Lampang Province.

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Abstract: The objectives of the research were to study the situation of the activity operation, problems and obstacles in promoting the well-being among the elderly in Wang Thong sub-district, Wang Nuea District, Lampang province and to find guideline of conducting activities and services that promote the well-being of the elderly. Data were collected by group discussion, in-depth interviews including analysis from documents the key informants were members of the elderly, scholars of The Wang Thong Sub-district Administration Organization, and local experts. Research instruments included an in-depth interview form and group discussion based on content analysis. The research found that conducting activities to support the well-being of the elderly through cooperation and supervision of The Wang Thong Sub-district Administration Organization along with community leaders and the elderly school has been assembled at Baan Saraphi, Village no. 6, starting from 2016 to 2018 with 559 members. The elderly school is the center for driving activities. The president of the Sub-district Administration Organization has taken care of and given support for site improvements. Moreover, the activities have continuously developed. In the beginning, the focus was on activities that promoted mental health. The elderly leadership group and members would like more activities to promote physical and mental health. Therefore, the current activities of the elderly consist of school attendance activities taking place on Tuesdays, activities for preserving culture and traditions, group activity for occupation, friend visit activities, group saving activities, etc. Regarding problems and obstacles in providing health support services for the elderly, in the past, most of the activities were conducted with care and help within the group. The lack of personnel of local agencies with closed care is another issue that needs to be given priority. The new generation of people prefers to move out of the community, causing the elderly to feel lonely, depressed, lacking motivation for living. In the past, although The Wang Thong Sub-district Administration Organization has supported some elderly people's health promotion, it still lacked systems and mechanisms for providing services, support for conducting activities that serve the needs of the elderly. Moreover, personnel from the Health Promoting Hospitals are limited and activities currently being run are not diverse. The finding of guidelines for activities that promote and support services for the well-being of the elderly in Wang Thong Sub-district, Wang Nuea District, Lampang Province, found that the elderly groups need activities that will increase support for balanced health consisting of social, intellectual, physical and mental health aspects. For promoting good health and happiness in living in the community, they prefer to have a chance to talk and conduct activities along with to meet friends of the elderly group members, and to have the opportunity to exchange ideas with each other. As the agreed resolution of the guidelines for additional activities are as follows: 1) Physical health promotion activities by adding more learning of exercise, aerobic dance, Paslop dance and yoga, 2) Activities creating a network of knowledge sharing which consists of creating common values in the community, communication within the group, outside the group and the community, promoting systematic presentation of the group's operations to be clear and effective, and 3) diversity of career grouping activities.

Keywords: Guidelines of Activity and Service Development, Promote the Well-Being, the Elderly.

1 INTRODUCTION

At present, the increase of the elderly population around the world is increasing rapidly, resulting in the starting point of entering society which is called "Aging Society", which has an impact on employment, social conditions and economic conditions. It includes resource management for the promotion of the environment and society of the country with quality continuously for the long-term (Pornthip Sukadisai, ChanChalee Maput, and Rungfah Kitiyanusan, 2014, page 92). According to the situation of the Thai elderly population in 2017, there are 11.7 million elderly aged 60 years and over, representing 16.9%. It is expected that Thailand will be the complete Aged Society. In 2021 or another 2 years in advance, there will be an aging population of 1 in 5. In 2019, it will be the first time that Thailand has a more aging population than the younger population, expecting that the population will enter the elderly aged 60 years or over, about 1 million people a year. The concern is that more than 30% of the Thai per-aging population still do not have the preparation to be quality elderly in the future, especially in the health dimension and income security (MGR Online, 2018). Changes in Thailand's population structure over the past 2-3 decades indicated that the proportion and number of the elderly population increased rapidly and continuously in 1994, the proportion of the elderly population was 6.8% and in 2002-2007 increased to 9.5% and 10.7% of population of the whole country respectively and was expected to increase to 13.4 percent in 2015 (National Statistical Office, 2007). Besides, it is predicted that in the next 25 years, Thailand will have the proportion of the elderly increased by 20.5 percent, causing the state and situation of Thailand to step into an Aging Society. Therefore, Thailand has an elderly population of more than 10%of the total population (Shryock, 2004). The age structure is represented by the proportion of the population of different ages. When classifying the population into 3 major age groups, it is namely the childhood population (younger than 15 years), labor age (aged 15-59 years) and the elderly (aged 60 years and over. It will find that between the years 2010-2040, the proportion of the childhood population and labor age tend to decrease while the proportion of the elderly population tends to increase continuously from 13.2% in 2010 to 32.1% in 2040. Furthermore, it should be noted that in 2017, the year in which the proportion of the childhood population is expected to be the same as the proportion of the elderly population. The proportion of the late elderly (over 80 years old) will increase from about 12.7 % of the total elderly population to almost 1 in 5 of the elderly population. This increase of the late elderly will reflect the aging of the population and lead to an increase of the dependency population both economic, social and health.

The Wang Thong Sub-district Administration Organization in Wang Nuea District, Lampang Province is aware of the problem, arising from the increase in the elderly and tends to have more elderly who live alone by taking the issues of community participation to help each other. Additionally, the operation is following the National Strategic Plan for Elderly People No. 2 (2002-2021) (Foundation for Elderly Research and Development Institute, 2015) applying The Wang Thong Sub-district Administration Organization and Wang Thong Health Promotion Hospital act as the main units for driving (Wang Thong Subdistrict Administration Organization, 2016). Consequently, the operation of the Sub-district Administration Organization will use the network to connect and coordinate to improve the health of the elderly in the Wang Thong Sub-district Hospital from the health promotion hospitals to the community. According to the basic data, it shows that Wang Thong Sub-district is under controlled by The administrative district of Wang Nuea District, Lampang Province, it consists of 7 villages namely Baan Tung Tai, Baan Tung Nuea, Baan Pong Tham, Baan Mae Yen, Baan Pa Lan, Baan Saraphi and Baan Pong Thong. The geographical feature is mountainous terrain In which villages no. 1-7 are located in the middle of the valley. The village no.4 Baan Mae Yen is near the district about 6 kilometers, and far from the district is 23 kilometers, which is Village No. 6 Baan Saraphi.

Surveying the context of research areas and preliminary information on the elderly, it was found 559 elderly in Wang Thong Sub-district, 160 elderly patients with chronic illnesses, and 8 elderly who cannot help themselves, and 73 disabled persons. Most of them have a desire to do activities together, want to meet each other to make the heart bright, not lonely. In the past, they participated in activities that the Administrative Organization has attempted to provide, but the problem was that some people lived in remote areas and had a lack of continuous promotion. Significantly, the administration has plans to promote the well-being of the elderly as well as government policies that are interested in the issue of the elderly, and the Office of Health

Promotion Fund, then it results in collaboration in this research.

2 OBJECTIVES

1. To study the situation of constructing activities, problems and obstacles in promoting the well-being of the elderly In Wang Thong Sub-district, Wang Nuea District, Lampang Province

2. To find guidelines to carry out activities that promote and support the well-being of the elderly in communities of Wang Thong Sub-district, Wang Nuea District, Lampang Province

3 RESEARCH METHODOLOGY

This research is qualitative research using Community-based participatory action research (CPAR) with elderly members in the community having the following details: scope of the research consisting of content scope, variable scope, and data source scope. The content scope has the content related to promoting well-being, well- being promotion activities based on the holistic health concept (Walter, 1999). Variable scope includes promoting well-being and well-being promotion activities. Data source scope has 2 types of data used in the research which are (1) data obtained from the research, evidence documents from concept studies, theory and review of relevant literature and (2). data collected from the field, data from observation, interviews, focus group among the elderly. The population studied was the elderly aged 60 years and over who live in the responsibility area of The Wang Thong Sub-district Administration Organization Wang Nuea District, Lampang Province. There were a total of 559 people. The research team selected 50 key informants, namely, the elderly club, members of leaders the elderly group leaders, 2 personnel of the Sub-district Administration Organization of Wangthong, and 2 local experts, a total of 54 villagers by using Purposive sampling (Rangsan Singhalert, 2008). The characteristics of the sample were as follows: (1) the elderly aged 60 years and over, (2) willing to participate in the health groups to develop their process of this research. As sampling techniques and methods, the researcher applied purposive sampling. The research instruments have been developed from a study of document reviews, textbooks, literature documents, concepts, theories, and related research including studies from the community's situation. The research instrument employed with a structured in-depth interview form which is a semi-structured interview in which questions and issues are needed for answering the research objectives. Techniques and methods for collecting data proceed was as follows; a practical research process by organizing a community forum on community situation and context needs of the elderly. Then, the researcher worked on the field by organizing activities and searching for activities that the elderly group members need. Since this research is a participatory qualitative research that focuses on the interaction of the members, therefore, data analysis applied content analysis and quality data checking using the Triangulation method. Statistics used was as descriptive statistics and participatory content analysis (Denzin, N. K. & Lincoln, Y. S., 1994).

4 FINDINGS

1. The results of general situation study were from interview and the secondary data analysis, the results of outcomes in well-being development among the elderly found that the total number of villages is 9 villages, 1,853 households, with an average density of 24 people / square kilometer. The total population is 5,530 people, divided into 2,692 males, 2,538 females, 559 elderly population, 160 persons having chronic illnesses, 8 persons without self-help and 73 disabilities. The number of the elderly is calculated as 10.11%, mostly female, marital status with primary school background. Moreover, they are Buddhism and 93% have participated in temple or religious activities quite often, 90% have participated in elder activities and community activities, 90% can live by themselves, and 65% live with spouses or 75% with children. Information about health problems is under the care of The Wang Thong Sub-district Administrative Organization. Wang Thong sub-district is located in Baan Pong Thong Village, Village no. 7, Wang Thong Sub-district, Wang Nuea District, Lampang Province, and it has started to develop local by establishing the district council management. It is located at Village no. 7, Baan Pong Thong Village, Wang Thong Sub-district, Wang Nuea District, Lampang Province, and was elevated as the Wang Thong Sub-district Administrative Organization in 1997. There were provisions to support social development which is the point that makes the development of public utilities, infrastructure, roads, electricity, water supply. A group of committees was formed to

carry out community activities, consisting of the elderly, housewives, cultural councils as well as the policy of the local government organization that has promoted, funded communities and people in need of access to information and funds in the technological knowledge area. Infrastructure development and public services must be worked to cover all areas. The village is a livable community surrounded by suitable conditions for quality of life. There is the effective management of natural resources and the environment, with an effective and efficient management system to provide good services to the people. Moreover, it promotes the public to have good health both physically and mentally, a good quality of life. The community is strong in every village.

Development or promotion of the elderly by the supervision of The Wang Thong Sub-district Administration Organization together with the community leaders and Than Thong Tong Tuaeng School. They have been organized together at Baan Saraphi as a headquarter, starting from 2016 to the present year 2018 for a total of 3 years with 559 members. The elderly school is the activity driver. The president of the Sub-district Administration Organization has closely looked after and his wife has also stayed beside in driving the activities of the elderly; beginning with site improvements which were formerly a wasteland of the community and carried out various seasonal activities and the context of the community has continuously developed activities. In the beginning, it will focus on activities that help promote mental health from participation in various community activities. However, elderly group leaders and members would like more activities to promote additional physical health to support each other for sustainable well-being. The activities of the elderly consist of:

1). School attendance activities on Tuesdays to meet with fellow members,

to attend learning activities about their health care, health check and singing

2). Activities for preserving culture and traditions In each festival according

to each context and customs

3). Activities for groupings for various occupations such as folk games, basketry occupation Group, artificial flower production group, herbal compress balls, etc.

4). Friend visits; those unable to participate in activities at Than Thong Tong Tung School or friends who stay the bed, getting sick or are old and unable to join the group's activities

5). The money-saving activity of the group; it depends on each person. This will fund the activities of the group as well as other benefits such as shopping for visiting friends, wreaths, hosting funerals for the elderly who have died, etc.

According to the problems and obstacles of the elderly, in the past, the activities to promote the well-being of the elderly were carried out mainly by caring for each other within the group and support from the president of The Wang Thong Sub-district Administration Organization. However, it is necessary to rely on the personnel of the local authorities to closely monitor, even if the president and wife are good supporters, but still need a specific caretaker. Particularly, the units are under the driving of the Sub-district Administration Organization as the main organization since the number of the elderly has increased. On the contrary, the younger generation who are children and currently in working-age would like to work in many different places. The elderly still live in the community, can work with age. Many people have a longer life expectancy, so they feel lonely, depressed, lacking grounds for motivation to continue living resulting in gaps and the desire for things to be fulfilled. In the past, The Wang Thong Sub-district Administration Organization has supported some of the elderly's health promotion, however; it still lacks systems and mechanisms for providing services, support to carry out activities that meet the needs of the elderly and efficient because the personnel responsible for providing services are not sufficient and personnel from the hospital are also limited. Moreover, current activities are not enough diverse. Activities that promote physical health at the same time With psychological promotion have the lack of budget supporters and government personnel is not enough to provide services for the elderly which has increased every year.

Figure 1: Brainstorming activity to analysis of needs and guidelines for health support of the elderly.

2. The result of finding guidelines for activities promoting and supporting the well-being of the elderly in communities of Wang Thong Sub-district, Wang Nuea District, Lampang Province, from a participatory action research to find or develop guidelines in implementing health promotion activities of the elderly group having a small group meeting, brainstorming session, it was found that the elderly group needed to receive balanced health care consisting of social, intellectual, physical and mental health, with a concise mechanism network. This elderly group has assembled for a while with the president of the Sub-district Administration Organization acting as the leader at the beginning of Than Thong Tong Tung School establishment, an elderly school in the sub-district. The members will become students, meet every Tuesday at Baan Mai, Village no. 6, Wang Thong Sub-district. Elderly members have diverse abilities as the group of making flowers for cremation, basketry groups, entertainment groups. The group members desire to do activities that can enhance their physical and mental capacity at the same time to promote well-being and happiness in their lives in the community. Moreover, they can meet friends of the elderly group members and have the opportunity to exchange views with each other. The members will bring lunch from home to eat together at school. It is sharing and exchanging as mind happiness. For the resolution that has been agreed to carry out activities to promote well-being, the elderly members have presented a wide variety, such as yoga, dance, retro band, exercising with the Paslop dance, etc. In consequence, the guidelines for activities that will be organized are as follows;

1. Physical health promotion activities: adding more learning exercise, aerobic dance, Paslop dance, yoga, yoga. Among all these needs, Paslop dance was resolved as the first activity to practice and learn together firstly since it can provide both physical benefits and happiness, relieve loneliness at the same time. There is a new ability to be used in the practice of living at home. A kind speaker from Baan Tung Tai Health Promotion Hospital was as a guest speaker and mentor for dance.

2. Activities to create a network of knowledge sharing to improve elderly well-being by collaborating with the research team funded by the Thai Health Promotion Agency

2.1 Creating common values in the community to maintain good

health both physic, mind, society, and intelligence by relying on the agencies that are responsible, such as Health Promotion Hospitals and the Sub-district Administration Organization in coordination with networks outside the community. This network created knowledge and practices for elderly members which requires activities at least 2 times a month.

2.2 Communication within the group, outside the group and outside the community: it had to manage and create a system of communication, organize communication within the group using both the LINE group, public relations through the voice of the village, and the leaders of each small group. As non-group communication, there was the use of activity creation with other groups for making friends, requiring activities at least twice a month. For communication with organizations outside the community, there was an assignment for the group leader to be responsible, then brought to communicate with the group members to create a system.

2.3 Systematic promotion of group presentation with effectiveness to be aware of the condition and situation of oneself and the group. Moreover, the network also receives information as well which will help in periodic tracking for the exchange of knowledge as well as evaluation. It will create appropriate plans and support correctly, according to the target group members with happiness.

3. Occupational integration activities: there is the awareness of the suitability for aptitude, market demand, therefore; there are additional herbal products and reuse of items

The next collaborative learning activity is Paslop dance serving the needs of the elderly members by inviting experts from Wang Yhong Health Promoting Hospital to help as trainers and practice In which the elderly people have a smiling face with happiness to participate in activities based on their needs. In addition, meeting the group of friends together is not lonely

and there is a network for living. Moreover, the president of The Wang Thong Sub-district Administration Organization also cares and gives importance to the elderly by joining to learn to dance with the elderly members almost every time.

Figure 2: Basalop dance workshop activity

Figure 3: Activity, community wisdom, and dance exercise

Figure 4: Other activities

5 DISCUSSION

The result of conducting a group meeting, participation in the discussion, brainstorming, exchanging and learning to find guidelines to improve the health of the elderly by cooperating with the elderly in Wang Thong Sub-district in Wang Nuea District, Lampang Province, is a guideline to promote the well-being during the free time of working. According to the elderly group which had the group meeting, organized a meeting, exchanged ideas, proposed and for the guidelines in conducting activities, they indicated that exercise and entertainment Including the joining of careers from existing networks, resources, knowledge, and local experiences from wisdom as well as resources that are both types of equipment, materials, people, departments result in the participation of all sectors in the community. According to the concept of Parichart Walaisatian et al. (2009) stated that the concept of participation in the sharing of people in the management, control, utilization, and distribution of resources including the factors of production that are in their locality. This is for the benefit of current economic and social living. The concepts of public participation in development are accepted and used as a guideline for practice in broad development. The participatory process is not defined by the state, but the success of the

participation is the people in the community or local, are the originators and focuses on group or organization working.

The needs of the elderly group after the group meeting, forum, resulting in the activity resolution, is an activity to increase happiness to promote well-being. In the first phase of the activity, Paslop dance is used as a rhythm for exercise every Tuesday at Than Thong Tong Tung School and can be used to exercise at home during leisure. The experts are invited Health Promotion Hospital to help train the dance skills. It is considered as an integration of local experts with the cooperation of the community network leading to spending time left over from a career in agriculture or causing the elderly to relieve loneliness with more bright hearts. It also adds new opportunities and skills through participation, helping each other by participating in activities to exchange knowledge, ideas, experiences from member groups, local experts, speakers from both inside and outside the community. It is the activity that promotes culture and tradition. This concept creates opportunity for new perspectives, which are consistent with the study of Kulwadee Rojphaisankit and Warakorn Kriangkraisakda (2017)that the activities for well-being of the elderly should be the creation of mental happiness, the opportunity to have a way to create well-being through physical health promotion activities, weekly meet-up activities, visiting the elderly home who stay in bed, self-care activities, elderly welfare activities, money-saving to support activities in the elderly which are well-being promotion activities.

RECOMMENDATIONS

Recommendations from research Based on the findings, the research team has recommendations regarding the Sub-district Administration Organization should assign personnel who are responsible for taking care of the work on the elderly for convenience and flexibility in carrying out and driving activities.

RECOMMENDATIONS FOR FURTHER RESEARCH

There should be research studies about the health care of the elderly to be in line with social and mental care to achieve a balanced condition in life.

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An Investigation into Factors Affecting Environmental Awareness of Primary School Children in Mon State, Myanmar

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Abstract: The main objective of this study is to study the factors affecting environmental awareness of primary school children. The specific objectives are (1) to investigate the level of primary school children's existing awareness towards environmental issues, (2) to investigate the variations of environmental awareness of primary school children according to their personal factors (3) to investigate the primary school children's level of participation in in-school experience, (4) to investigate the primary school children's level of participation in out-of-school experience, (5) to investigate the level of interest and concern of primary school children towards environmental issues, and (6) to identify the factors affecting environmental awareness of primary school children. Quantitative and qualitative methods were used in this study. The validity of the questionnaires was taken from 11 experts. The reliability coefficient (Cronbach's Alpha) of the questionnaire was 0.83. A total of 354 primary school children participated in this study. For analyzing quantitative data, Descriptive statistics, Item Percent Correct, Independent Samples *t* Test, One-Way ANOVA, post-hoc test by Tukey, and Multiple Regression were used. For qualitative study, observation was also employed. In analyzing qualitative data, the cyclical process was used. As a result, it was found that most of the primary school children had satisfactory level of environmental awareness. Regarding the factors affecting primary school children's environmental awareness, the first predictor was their concern towards environmental issues (concern about water pollution, air pollution) and the second one was their out-of-school experience (observing different types of plants and animals in natural environment). Qualitative study revealed that children who got the opportunity to connect the lesson with the natural environment are more environmentally aware than children who got a little opportunity on such kinds of experience.

Keywords: Environmental Awareness, In-school Experience, Out-of-school Experience

1 INTRODUCTION

Many scholars claimed that natural resources are limited and degradation of natural environment and climate change are greatest challenges for 21st century in this world. Some academicians also point out that environmental issues are the first priority matters for policy makers and leader of States in addressing the global problem and the effect of globalization.

For solving the existing environmental crisis, the education system should emphasize on promoting environmental awareness and proper understanding of the environment. According to Jackson (2005), creating environmental awareness among students is one of the best ways to preserve the environment.

In order to strengthen knowledge and understanding about the environment and be more aware on the world's current condition, school, parents and community need to collaborate to convey adequate awareness and inculcate the right environmental attitudes in young generation, especially children

1.1 Significance of the Study

In the 2014 Environmental Performance Index (EPI) which was used in measuring countries' environmental management status, Myanmar ranks 164 out of the 178 countries and is among the world's least developed in environmental management and regulation. Issue concerning with forest resources is the strongest environmental problem in Myanmar and it is one of the contribution factors to the loss of biodiversity. Moreover, issues related to air pollution, water pollution and land pollution are also raised in Myanmar (Raitzer, Samson, and Kee-Yung Nam, 2015).

Environmental issues often arise from a lack of understanding of nature and the ecology environment and inappropriate use of natural resources. The international community has increasingly come to understand the importance of environmental education to environmental protection. Developing and strengthening of environmental awareness and encouraging everybody to pay attention and to protect the common environment is the fundamental solution for the environmental problem.

As Hungerford (2003) stated that individuals' sensitivity to the environment, knowledge and use of citizenship action skills and individuals' accountability for the environment affect environmental citizenship. Hence, there is a strong need to have the awareness for conserving the environment and the school where cultivating the young children and the community should provide knowledge to students for promoting awareness and developing positive attitudes towards environment. The school is the major venue for developing environmental awareness.

Environmental education assists the development of knowledge, skills and values that promote behaviour for sustainable environment. UNESCO's SDGs Learning objectives guideline (2017) also suggest that education officials, policy-makers, educators, curriculum developers and others are called upon to rethink education in order to contribute to the achievement of the SDGs within their timeframe, between now and 2030. As a consequence, some projects and programs are needed to establish immediately to meet the requirements of 2030 goals.

Keeping in mind these issues, it was intended to find out the factors affecting the environmental awareness of primary school children in Chaungzone Township, Mon State, Myanmar.

1.2 Objectives of the Study

The objectives of the study are as follow:

1.2.1 General Objective

The general objective of the study is to investigate factors affecting environmental awareness of primary school children.

1.2.2 Specific Objectives

The specific objectives of the study are

(1) to investigate the level of primary school children's existing awareness towards environmental issues
(2) to investigate the variations of environmental awareness of primary school children according to their personal factors
(3) to investigate the primary school children's level of participation in in-school experience,
(4) to investigate the primary school children's level of participation in out-of-school experience
(5) to investigate the level of interest and concern of primary school children towards environmental issues
(6) to identify the factors affecting environmental awareness of primary school children

1.2.3 Research Questions

The research questions of the study are

(1) What is the level of primary school children's existing awareness towards environmental issues?

(2) Is there any variation in the environmental awareness of primary school children according to their personal factors?

(3) To what extent do the primary school children participate in in-school experience?

(4) To what extent do the primary school children participate in out-of-school experience?

(5) What are the levels of interest and concern of primary school children towards environmental issues?

(6) What are the factors affecting environmental awareness of primary school children?

2 THEORETICAL FRAMEWORK

The following theoretical framework was used in this study.

According to the tree model presented by Palmer, in order for children to be able to react reasonably to environmental problems, school should present knowledge created by different branches of science. The top of the tree contains three intersecting sections. Education about the environment stresses experience, studying and gaining information, which serve decision making and evaluation. While information come from problems concerning students personally, this element is closely related with the ethical aspect of this model. Teaching in/from the environment concerns developing studying methods and using nature throughout the education and this is inert knowledge. Education for the environment introduces taking nature into account. This is to guide behaviour and to develop personal relationship to nature and to stress personal activity. Even though improving of attitudes aims to wide appreciation and conservation of nature, it is not a question of single-minded protection.

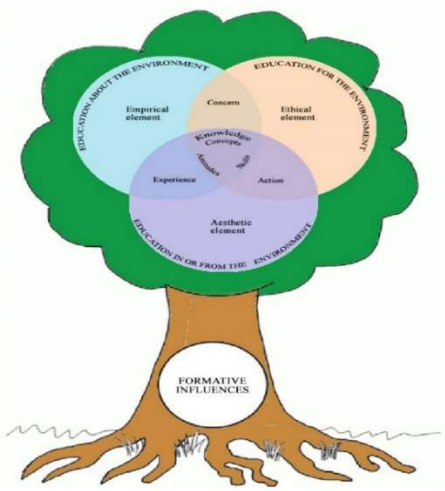

Figure 1. Palmer's Tree Model for Environmental Education

Source: From Palmer (1998). Environmental Education of the 21st century: Theory, Practice

Even though improving of attitudes aims to wide appreciation and conservation of nature, it is not a question of single-minded protection. The core in the intersection cannot be reached by educational programs, although it interacts with then, feeding other experiences. Formative influences depicted as roots remind that teaching is more likely to succeed, if it grounds itself in students' earlier information (Palmer, 1998).

Bronfenbrenner (1994) also stated the ecological system in which growth occurs. This system is composed of five socially organized subsystems that help support and guide human growth.

- Microsystem: It includes family, school, peer group, neighbourhood and workplace.
- Mesosystem: It is the connections between family experiences and school experiences, and between family and peers.
- Ecosystem: It comprises the linkages and processes taking place between two or more setting, at least one of which does not contain the developing person, but in which events occur that indirectly influence processes within the immediate setting in which the developing person lives.
- Macro system: It is encompassing context in which students and teachers live, including the society' values and customs. Socioeconomic status can have important effects on students' school performance.

- Chronosystem: It includes the sociohistorical conditions of students' development (Bronfenbrenner, 1994).

Bronfenbrenner's theory has been instrumental in showing how different contexts of children's lives are interconnected. It should be taken into account that the children are embedded in a number of environmental systems and influences such as school and teachers, parents and siblings, the community and neighbourhood, peers and friends, the media, religion and culture. Hence, it is important to pay attention to the connection between schools and communities and recognize the importance of the community, socioeconomic status, and culture in the child's development (Santrock, 2008).

2.1 Definition of Key Term

Environmental Awareness is defined as conscious of the problem and dangers facing mankind and environment and pressing need for positive action to control the dangers undesirable impact of man activities and demand upon the environment (Environmental Education Committee, Kenyatta University College, 1980, cited in Boiyo, 2014).

2.2 Operational Definition

In this study, **Environmental Awareness** is operationally defined as the children's awareness of the problems concerning conservation of resources, pollution, and general issues and positive action to control these problems and it was measured by using Item Percent Correct (IPC) values.

In-school experience is operationally defined as the experience that involves children in playing and visiting in the school park, inquiring the nature of plants and animals, investigating environmental issues, and participating in environmental education activities in the school environment.

Out-of-school experience is operationally defined as the experiences that involves recreation in nature, observing different types of plants and animals in, inquiring types of water and soil in local environment.

3 METHODOLOGY

Quantitative and qualitative methods were used in this study.

3.1 Quantative Study

For quantitative study, descriptive research design was used and data were collected through questionnaire.

3.1.1 Sample

The participants of this study were primary school children who are attending in Grade IV in Chaungzone Township, Mon State. In order to collect the required information, 354 primary school children were selected from Basic Education Primary Schools, Basic Education Middle Schools and Basic Education High Schools in Chaungzone Township by using proportional stratified sampling method.

3.1.2 Instrumentation

Questionnaire survey was used in this study so as to collect the required data for the study. There were 5 items for demographic data, 23 items for investigating the existing environmental awareness of primary school children, 19 items for in-school experience, 10 items for out-of-school experience, and 10 items for their interest and 10 items for concern towards environmental issues. The Demographic data includes gender, school, father's work, mother's work, father's education level, and mother's education level. Environmental awareness was made up of three components: conservation of resources, pollution, and general issues. These items were developed as multiple-choice items. In-school experience, includes 19 items. These items were developed as five-point Likert-type items: (1=never, 2=seldom, 3=sometimes, 4=often, 5=always). For out-of-school experience, it involves 10 items. These items were also developed as five-point Likert-type items: (1=never, 2=seldom, 3=sometimes, 4=often, 5=always). Regarding interest towards environmental issues, it consisted of 10 items. The items were developed as five-point Likert-type items: (1=not interested, 2=slightly interested, 3=moderately interested, 4=very interested, 5=extremely interested). Regarding concern towards environmental issues, it consisted of 10 items These items were also developed as five-point Likert-type items: (1=not concerned, 2=slightly concerned, 3=moderately concerned, 4=very concerned, 5=extremely concerned). According to the result of pilot testing, the internal consistency (Cronbach alpha) was 0.83.

3.1.3 Procedure

A set of questionnaire was developed after reviewing related literature. For content validity, the advice and guidance were taken from the 11 expert educators who have special knowledge and experience in the field of this study.

Pilot study was conducted with 40 primary school children from three Basic Education Primary Schools in Mayangone Township, Yangon Region. After conducting pilot study, the questionnaire was modified.

To collect the required data at the selected Basic Education, permission was granted by the Department of Basic Education. The modified questionnaire was distributed to 354 primary school children from 38 Basic Education Schools including Basic Education High Schools, Basic Education Branch High School, Basic Education Middle Schools, Basic Education Branch Middle School, Basic Education Primary Schools and Basic Education Post Primary School. After two weeks, the questioonaire were collected. A valid response rate was 100%

3.1.4 Analysis of Data

In this study, the descriptive method of research was used. The collected data of this study were systematically analyzed by using the Statistical Package for the Social Science software version 22 as it is widely used in quantitative research.

3.2 Qualitative Study

In addition to quantitative method, the researcher also used qualitative method to get more definite information about factors affecting primary school children awareness towards environmental issues.

The researcher selected purposively ten schools based on the results of quantitative data analysis. The schools were divided into two groups, Group A and Group B. Group A Schools were schools with highest mean score of Environmental Awareness and Group B schools were schools with the lowest mean score of Environmental Awareness.

After reviewing quantitative questionnaires, observation checklist was developed. The expert teachers gave the advice and necessary guidance. After expert validation, qualitative data was gathered.

Observation intended to study the environment of the schools, waste management and eco-friendly behavior of the children and environmental awareness and attitudes raising activities. Observation checklist was organized with 9 items. During observation, the researcher investigated whether the school environment had the plants and flowers cultivated by children and whether there were the shady trees for children to play beneath them. Concerning waste management, whether the children sorted out the waste when they threw it, whether they create new products with the recycle materials and whether they threw the liters systematically were observed. Besides, teachers' classroom teaching was observed in order to investigate whether they connect the lesson with the natural environment.

Data analysis was conducted based on categorizing and interpreting the observation. The cyclical process was used in order to analyze the qualitative data. After collecting the data, they were thoroughly studied to become familiar with the data and to identify potential themes. By interpreting and synthesizing the organized data and comparing to one another, information from the school environment and classroom teaching were complementary to each other.

4 FINDINGS

4.1 Quantitative Findings

In the quantative study, environmental awareness of primary school children their in-school experience, out-of-school experience, interest and concern towards environmental issues were investigated.

4.1.1 Findings on primary school children's existing awareness towards environmental issues

Table 1. Numbers and Percentages of Primary School Children Showing the Level of Environmental Awareness on Conservation of Resources (N = 354)

Scoring Range	No. of Students	Remark
<50%	8 (2%)	Below Satisfactory Level
50%-74%	163(46%)	Satisfactory Level
≥75%	183 (52%)	Above Satisfactory Level

Scoring range:
<50% = Below Satisfactory
50%-74% = Satisfactory
≥75% = Above Satisfactory

According to the scoring range, 8 (2%) of total students were below satisfactory level, 163 (46%) of total students were in satisfactory level and 183 (52%) of total students were above satisfactory level.

In Table 2, numbers and percentages of primary school children showing the level of environmental awareness on pollution were presented.

Table 2. Numbers and Percentages of Primary School Children Showing the Level of Environmental Awareness on Pollution (N=354)

Scoring Range	No. of Students	Remark
<50%	41 (11%)	Below Satisfactory Level
50%-74%	102 (29%)	Satisfactory Level
≥75%	211 (60%)	Above Satisfactory Level

Scoring range:
<50% = Below Satisfactory
50%-74% = Satisfactory
≥75% = Above Satisfactory

According to table 2, 41 (11%) of total students were below satisfactory level, 102 (29%) of total students were in satisfactory level and 211 (60%) students were above satisfactory level.

Table 3 shows the numbers and percentages of primary school children's environmental awareness on general issues.

Table 3. Numbers and Percentages of Primary School Children Showing the Level of Environmental Awareness on General Issues (N=354)

Scoring Range	No. of Students	Remark
<50%	107 (30%)	Below Satisfactory Level
50%-74%	166 (47%)	Satisfactory Level
≥75%	81 (23%)	Above Satisfactory Level

Scoring range:
<50% = Below Satisfactory
50%-74% = Satisfactory
≥75% = Above Satisfactory

According to Table 3, 107 (30%) of total students were below satisfactory level, 166 (47%) of total students were in satisfactory level and 81 (23%) of total students were above satisfactory level.

Table 4. Numbers and Percentages of Primary School Children Showing the Level of Environmental Awareness (N=354)

Scoring Range	No. of Students	Remark
<50%	53 (15%)	Below Satisfactory Level
50%-74%	154 (43%)	Satisfactory Level
≥75%	147 (42%)	Above Satisfactory Level

Scoring range:
<50% = Below Satisfactory
50%-74% = Satisfactory
≥75% = Above Satisfactory

According to Table 4, 53 (15%) of total students were below satisfactory level, 154 (43%) of students were in satisfactory level, and 147 (42%) of total students were above satisfactory level. It was shown in Figure (2).

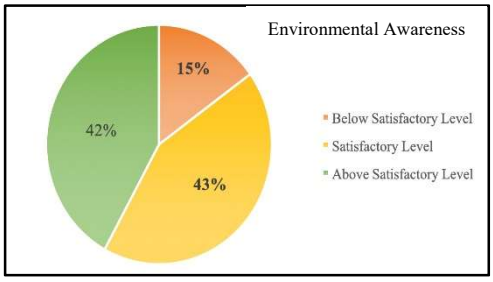

Figure 2. Percentages of Children Showing the Level of Environmental Awareness

4.1.2 Findings on the variations of primary school children's existing awareness towards environmental issues

Table 5. Mean Scores and Standard Deviations of Primary School Children's Environmental Awareness Grouped by Gender (N=354)

Variable	Gender	No. of Students	Mean	SD
Environmental Awareness	Male	160	16.38	3.80
	Female	194	16.00	3.67

According to Table 5, the male students' mean score was 16.38 and the female ones' mean score was 16.00. It can be noted that the mean score of male students was higher than that of female students.

Table 6. Independent Samples *t* Test Showing Primary School Children's Environmental Awareness Grouped by Gender (N=354)

Variable	Gender	*t*	*df*	*p*
Environmental Awareness	Male	.942	352	ns
	Female			

*p<.05, **p<.01, ***p<0.001, ns= not significant

The independent samples *t* test was conducted for the primary school children's environmental awareness according to gender. It was found that there was no significant difference in environmental awareness between male students and female students (p>0.05).

Table 7. Mean Scores and Standard Deviations of Primary School Children's Environmental Awareness Grouped by Father's Education Level (N=354)

Variable	Father's Education Level	Mean	SD
Environmental Awareness	No Schooling	14.88	4.06
	Primary School	15.80	3.81
	Middle School	16.52	3.82
	High School	16.44	3.49
	Graduate	16.70	3.14
	Average	16.17	3.73

According to Table 7, it was found that the mean scores of students whose father's education was graduated were the highest mean score and those of students whose father's education were no schooling was the lowest mean score.

Table 8 One-Way ANOVA Result Showing Primary School Children's Environmental Awareness Grouped by Father's Education Level (N=354)

Variable		Sum of Squares	*df*	Mean Square	*F*	*p*
Environ-mental Aware-ness	Between Groups	70.987	4	17.747	1.282	ns
	Within Groups	4830.844	349	13.842		
	Total	4901.831	353			

*p<.05, **p<.01, ***p<0.001, ns= not significant

According to Table 8, there was no significant variation on the environmental awareness (p>0.05) among the students grouped by their father's education.

Table 9. Mean Scores and Standard Deviations of Primary School Children's Environmental Awareness Grouped by Mother's Education Level (N=354)

Variable	Mother's Education Level	Mean	SD
Environmental Awareness	No Schooling	13.71	4.30
	Primary School	16.24	3.80
	Middle School	16.44	3.63
	High School	16.12	3.70
	Graduate	16.21	3.33
	Average	16.17	3.73

According to Table 9, it was found that students whose mother's education with middle school were the highest mean score and those whose mother's education with no schooling were the lowest mean score.

Table 10. One-Way ANOVA Result Showing Primary School Children's Environmental Awareness Grouped by Mother's Education Level (N=354)

Variable		Sum of Squares	*df*	Mean Square	*F*	*p*
Environ-mental Aware-ness	Between Groups	92.229	4	23.057	1.673	ns
	Within Groups	4809.601	349	13.781		
	Total	4901.831	353			

*p<.05, **p<.01, ***p<0.001, ns= not significant

According to Ttable 10, there was no significant difference in their environmental awareness according to their mother's qualification (p>0.05).

Table 11. Mean Scores and Standard Deviations of Primary School Children's Environmental Awareness Grouped by School Group (N=354)

Variable	School Group	Mean	SD
Environmental Awareness	Group 1	16.30	3.91
	Group 2	14.34	2.36
	Group 3	16.77	3.43
	Average	16.17	3.73

Notes:
Group 1= Basic Education Primary Schools and Basic Education Post Primary Schools.
Group 2 = Basic Education Middle Schools and Basic Education Middle Schools (Branch).
Group 3 = Basic Education High Schools and Basic Education High Schools (Branch).

According to Table 11, it was found that the primary school children from Group 1 schools were with the highest mean score concerning with environmental awareness and the children from Group 2 Schools were with the lowest mean scores concerning with environmental awareness.

Table 12 One-Way ANOVA Result Showing Primary School Children's Environmental Awareness Grouped by School Group (N=354)

Variable		Sum of Squares	*df*	Mean Square	*F*	*p*
Environ-mental Aware-nsess	Between Group	166.803	2	83.402	6.182	.002**
	Within Group	4735.027	351	13.49		
	Total	4901.831	353			

*p<.05, **p<.01, ***p<0.001, ns= not significant

According to One-Way ANOVA result, it was found that there was a significant difference in environmental awareness of primary school children among school groups (p<.01).

Table 13. Tukey HSD Result Showing Primary School Children's Environmental Awareness Grouped by School Group
(N=354)

Variable	(I) School	(J) School	Mean Difference (I-J)	*p*
Environmental Awareness	Group 2	Group 1	-1.963*	.005**
		Group 3	-2.430*	.002**

*p<.05, **p<.01, ***p<0.001, ns= not significant

According to Table 13, Post hoc Tukey test indicates that there were significant differences in environmental awareness between children from Group 1 schools and Group 2 schools (p<.05), and between children from Group 2 schools and Group 3 schools (p<.05).

4.1.3 Findings on the level of primary school children's participation in in-school experience

Table 14. Mean Values and Standard Deviations of Primary School Children's In-school Experiences (N=354)

No.	Items	Mean	SD
1.	Playing in the surroundings of school compound	3.12	1.37
2.	Playing in garden of the school compound	2.41	1.77
3.	Participating in cultivating flowers and plants in school	3.26	1.41
4	Observing the growth of plants	2.75	1.16
5	Investigating various parts of plants in the school compound	2.72	1.25
6	Investigating different types of flowers, plants and trees in the school compound	3.01	1.23
7	Observing the soil types where the plants are growing	2.72	1.22
8	Making souvenir with the products obtained from the natural environment	2.64	1.61
9	Creating toys and souvenir with the waste products	2.05	1.25
10	Investigating various types of insects and animals that exist in the school compound	2.21	1.17
11	Observing the growth of the plants that are cultivated by themselves	2.99	1.12
12	Collecting and presenting the information concerning environmental issues in the school	2.37	1.31
13	Telling stories about the environment, animals and forest to others	2.64	1.09
14	Participating in impromptu talk and debate concerning the environment, animals and forest	1.89	1.11
15	Participating in essay competition concerning the environment, animals and forest	2.29	1.62
16	Listening to the lecture concerning the environment, animals and forest	2.58	1.10
17	Watching movies and television about the environment, animals and forest	3.06	1.21
18	Surveying books and magazines about the environment, animals and forest in the school library	2.75	1.17
19	Watering flowers and plants in the school compound everyday.	3.14	1.49
	Average	2.67	0.65

Scoring range:
1.00-1.80 =never, 1.81-2.60 =seldom,
2.61-3.40=sometimes, 3.41-4.20 =often,
4.21-5.00=always

In participating in in-school experience, it was found that the item with the highest mean value was item 3 (Mean=3.26) and the item with the lowest mean value was item 14 (Mean=1.89). It can be noted that primary school children sometimes participate in cultivating flowers and plants in school and seldom participate in impromptu talk and debate concerning to the environment, animals and forest. The average mean value was 2.67. It can be noted that the children sometimes participated in in-school experience.

4.1.4 Findings on the level of primary school children's participation in out-of-school experience

Table 15. Mean Values and Standard Deviations of Primary School Children's Out- of-school Experience (N=354)

No.	Items	Mean	SD
1.	Going a picnic to forest and mountain	1.75	0.97
2.	Playing and wandering along the river and forest	1.91	1.31
3.	Observing birds and animals in the nature	2.09	1.12
4.	Planting flowers and trees in the home surrounding	3.35	1.20
5.	Observing animals in the home surrounding	2.87	2.00

6.	Investigating the type of water in the local area	2.23	1.19
7.	Investigating the type of soil in the local area	2.18	1.13
8.	Visiting to the zoo	2.19	1.07
9.	Going a field-trip to farm	2.53	1.16
10.	Discovering to the place where crops are growing	2.79	1.31
	Average	2.39	0.69

Scoring range:
1.00-1.80 =never, 1.81-2.60 =seldom,
2.61-3.40=sometimes, 3.41-4.20 =often
4.21-5.00=always

According to Table 15, it was found that the item with highest mean value was item 4 (Mean=3.35) and the item with the lowest mean score was item 1(Mean=1.75). It can be noted that primary school children were sometimes participated in planting flowers and trees in the home surrounding and never going a picnic to forest and mountain. The average mean value for out-of-school experience was 2.39. It was found that they seldom participated in out-of-school experience.

4.1.5 Findings on the level of primary school children's interest and concern towards environmental issues

Table 16. Mean Values and Standard Deviations of Primary School Children's Interest towards Environmental Issues (N=354)

No.	Items	Interest		Concern	
		Mean	SD	Mean	SD
1.	Deforestation	3.40	1.21	3.59	1.52
2.	Energy Scarcity	2.74	1.30	2.83	1.26
3.	Water Scarcity	3.78	1.21	3.93	1.20
4.	Air pollution	2.84	1.28	3.08	1.25
5.	Water pollution	3.16	1.28	3.38	1.27
6.	Soil pollution	3.29	1.28	3.50	1.20
7.	Garbage	3.22	1.32	3.43	1.25
8.	Endangered species	3.39	1.33	3.53	1.28
9.	Global Warming	3.76	1.33	3.94	1.27
10.	Unusual heavy rain and flooding	4.02	1.23	4.23	1.11
	Average	3.36	0.84	3.54	0.79

Scoring range:

Interest:	Concern:
1.00-1.80 = not interested	1.00-1.80 = not concerned
1.81-2.60 = slightly interested	1.81-2.60 = slightly concerned
2.61-3.40 = moderately interested	2.61-3.40 = moderately concerned
3.41-4.20 = very interested	3.41-4.20 = very concerned
4.21-5.00 = extremely interested	4.21-5.00 = extremely concerned

According to Table 16, concerning Interest towards Environmental Issues, the item with the highest mean value was item 10 (Mean=4.02) and the item with the lowest mean value was item 2 (Mean= 2.74). It can be noted that children were very interested in the issues of unusual heavy rain and flooding, moderately interested in the issues of energy scarcity. The average mean value was 3.36. It can be noted that primary school children were very interest in environmental issues.

For Environmental Concern, the item with the highest mean value was item 10 (Mean=4.23) and the item with the lowest mean score was item 2 (Mean=2.83). It can be noted that children were extremely concerned in the issues of unusual heavy rain and flooding, moderately concerned in the issues of energy scarcity. The average mean value was 3.54. It can be regarded that primary school children were very concerned towards environmental issues.

4.1.6 Findings on Potential Factors Affecting Environmental Awareness of Primary School Children

Five variables were identified as predictors of primary school children's environmental awareness: In-school Experience (IE), Out-of-school Experience (OE), Interest (I), Concern(C), and School Level (SL). Simultaneous multiple regression was conducted to investigate the best predictor of their Environmental Awareness. The combination of variables for predicting Environmental Awareness included In-school Experience (IE), Out-of-school Experience (OE), Interest (I), Concern(C), and School Group (SG), F (5,348) = 9.222.

In Table 17, it was found that primary school children's environmental awareness was positively and significantly correlated with their in-school experiences, out-of-school experiences, interests and concern towards environmental issues. However, it was negatively associated with school group.

Table 17. Mean Values, Standard Deviations and Inter-correlations for Primary School Children's Environmental Awareness and Predictor Variables

Vari-able	Mean (SD)	IE	OE	I	C	SG
EA	2.27 (.70)	.211***	.225***	.230***	.307***	.070
Predictor Variables						
IE	1.75 (.58)		.451***	.207***	.235***	-.081
OE	1.55 (.57)			.305***	.253***	-.001
I	2.27 (.69)				.722***	-.003
C	2.42 (.64)					.005
SG	1.51 (.80)					

*p<.05, **p<.01, ***p<0.001

Table 18. Simultaneous Multiple Regression Analysis for Factor Predicting Primary School Children's Environmental Awareness

Variables	B	SEB	β	p
In-school Experience	.11	.07	.11	.051
Out-of-school Experience	.14	.07	.12*	.049
Interest	.03	.08	.03	.732
Concern	.22	.08	.20**	.006
School Group	.07	.04	.08	.123
Constant	1.11	.18		.000

R=.34, R^2 = 11, F (5,348) = 9.222
*p<.05, **p<.01, ***p<0.001

The Beta coefficients were presented in the table. Out-of-school experience of the children and their concern towards environmental issues significantly predicted their environmental awareness when all five variables were included. The adjusted R squared value was .11 (R=.34).

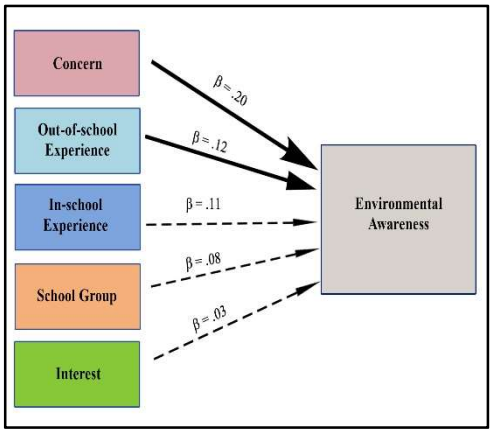

Figure 3. Potential Factors Affecting Primary School Children's Environmental Awareness

Notes:

- - - - - - - - - → Predicting on children's environmental awareness (not significant)

——————→ Predicting on children's environmental awareness (statistically significant)

This indicated that 11% of the variance in children's awareness towards environmental issues was explained by the model, and this is smaller than typical effect according to Cohen (1988). According to Beta weights, concern towards environmental issues variable (β = .20, p<.01) appears to be the best predictable of children's environmental awareness. Out-of-school experience variable (β = .12, p< .05) appears to be the second predictor of children's environmental awareness. Moreover, children's in-school experience, their interest towards environmental issues and the school group appear to be important for their environmental awareness.

4.2 Qualitative Findings

In order to examine the school environment and the environmental education activities of the school, five schools from Group (A) and five schools from Group (B) were selected purposively to observe. The observation was organized into three categories to realize the factors affecting environmental awareness of primary school children. These are investigation of environmental setting around the school, environmentally friendly behavior of the students and teaching-learning activities relating to environmental awareness.

The first category is dealing with circumstance of environmental setting around the schools. The investigation carried out on the issues, "Are there trees planted by students around the school compound? "Are there the shay trees available throughout the school to make students playing and relaxed?" and the next form of exploration is "Observing the cultivation of flowering plants around the school."

The observation was also carried out to investigate whether the students have the habits of throwing the rubbish properly and collecting the plastics cans and recyclable items systematically. Moreover, the application of recyclable items into souvenirs was also observed.

The last category is analysis on the degree of facilitation and the performance on awareness program about the school atmosphere.

Regarding question 1, over half of the percentages of Group A schools (60%) performed the activity of cultivation of plants in school and this task was carried out by students. In contrast, the rest of under a half of percentage (40%) did not participate in this activity. In contrast, Group (B) schools portray that under a significant minority (20%) were actively performed in it and

the rest of the schools (60%) did not activate in this plantation movement.

Large amount of big trees was grown along the fence of the school. However, it was discovered that there was no plant which was cultivated by students. It was evidence that the majority of Group (A) schools (80%) and (B) schools (20%), were in green environment, while the rest of the schools were found in opposite situation.

Accordingly, gardening activities of students around the schools were also observed. The study observed to what extent the children participated in these activities. In a school garden, with the cooperation and guiding of the teachers, the children were set to cultivate and water plants and flowers and hence the school compound was greening and beautifully decorated with colourful flowers. The children got the opportunity of wandering around the school to classify different types and size of plants. The result of assessing stated that 3 schools (60%) of Group (A) performed this activity. However, it was not observed that the rest of the schools from Group (A) and all of Group (B) schools (100%) performed the activities concerning gardening.

The observation also carried out how students utilize the recyclable waste wisely. As a sequence, the observation scope was laid down under the title of - "innovation of students which is transformation of recyclable wastes into the souvenirs." It was observed that 20% of Group A schools performed such kind of activity, however, 80% of them did not involve in this activity. Then, all of the Group (B) schools failed to implement on this exertion.

Observation also carried out the garbage management system of the schools. As a result, a very significant outcome was uncovered that both Group (A) and Group (B) schools have effective waste management system because they throw their garbage to the dump site properly.

Providing the sufficient facilities is also a crucial point for the establishment of effective waste management system. For this reason, observation was also carried out what kind of materials was provided; the adequate amount of dustbin is available or not in all schools. It was observed that not only Group (A) schools but also Group (B) schools can provide sufficient amount of dustbin in all schools.

Observation was also examined on arrangement of activities to raise the environmental awareness and attitude of primary school children. It was observed that neither Group (A) nor Group (B) schools organized such kind of activities as essay competitions, impromptu talk.

Moreover, magazines and journals like shwethwe, thu-ta-yadanar-tike made available to students. One of these schools was unique with other schools in that it has dustbins which were hung on to the large trees in order to throw the litters conveniently.

It was found that two schools with high mean score of environmental awareness (40%) applied the schoolyard as a classroom for the purpose of connecting the lessons with natural environment.

It was also found that one of the teachers from the schools with students of high environmental awareness used real objects from the environment while he was teaching. As the lesson was about waterlily (kyar-hsit-kyoe), the teacher took the real plants of water-lily from a lake as a teaching aid. Before the lesson started, he made his students familiar with water-lily and taught them the way of making a necklace with this plant. The children enjoyed in this activity and he also said that if students obtained the opportunity to learn by using their senses, they were more interested in the lesson and had a feeling of loving nature. Although he could not bring all of the students to the place where water-lily grows, he could create the classroom environment like real setting.

To sum up, Group A schools had more green environment than Group B schools. It was also found that both Group A schools and Group B school had magazines and journals about plants and animals. Group A schools had more participation in connecting the lesson with the natural environment during teaching.

5 CONCLUSIONS

Regarding environmental awareness, most of the primary school children had satisfactory level of awareness towards environmental issues. Regarding environmental awareness grouped by father's and mother's education level, ANOVA result showed that there was no significant difference in environmental awareness according to their father's and mother's education levels. According to the school group, ANOVA result indicated that there were significant differences in environmental awareness of primary school children among school groups. Concerning in-school experience of the primary school children, they sometimes participated in in-school experience. As out-of-school experience, it was found that they seldom participated in out-of-

school experience. Regrading interest and concern towards environmental issues, children were very interested in environmental issues and very concerned to environmental issues. According to the result of simultaneous multiple regression, it can be concluded that concern towards environmental issues becomes the best predictor for environmental awareness. Out-of-school experience becomes the second predictor for environmental awareness. The results of observation revealed that some schools had green environment, but cultivation of plants by students themselves was rarely occurred. Most of the schools had magazines, journal and books were arranged in the school library. The children who got the experience to connect the lesson with the natural environment are more environmentally aware than those of other. But a few schools displayed the connection of lesson with the natural environment.

5.1 Suggestions

1. Children should be given the opportunities to engage in the activities of education in the environment, education about the environment and education for the environment.
2. School should collaborate with environmental educators to foster environmental literacy of primary school children by engaging them in activities.
3. Every school should have adequate arrangements for planning and implementing a programme of environmental education.
4. Classroom should be decorated with some educational infographic tools like posters, photographs, charts and informative artworks to raise environmental awareness of the children.
5. School should use a range of resources in teaching environmental education including trips to museums, gardens, backyards, wetlands, national parks, camping, building trees houses, etc.
6. School should include environmental studies as part of the extra-curricular activities. This can enable the children to receive the education needed to understand many facets associated with environmental protection and conservation.
7. Livelihood program should create for all stakeholders because the carrier opportunity for local people can draw up the community under poverty line.
8. Environmental Education (EE) should be integrated and implemented in every subject of the curriculum.

5.2 Need for Further Study

Further studies need to investigates parents' and teachers' perception and practices of environmental education for enhancing children environmental awareness.

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Long Term Care Digital Innovation Platform: the sustainable preparing for healthy aging society

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Abstract: Preventive healthcare has been focused to consider as a part of the policies for Thai people. Especially, the preparing of healthcare system for elderly has been worldwide implemented for the coming of super-aged society by 2035. Due to higher incidence of aging population, this shift in demographic affects the propotion of elderly and shortage of caregivers as well as extremely higher burden and costs in elderly care. Therefore, the sustainable preparing in healthcare system will help decrease the risk of overpopulation need in the medical service. Here, we propose the solution for the sustainable preparing for healthy aging society with long term care (LTC) digital innovation platform. We support the caregivers and doctor to closely monitor and immediately predict the elderly's health status. All health monitoring report will be able to show on doctor screen or LTC app on smart phone or tablet when the QR code on the individual smart card was in couple of minutes scanned. Use case of LTC application was implemented with 10 elderly represented in Khon Kaen Province. The first phase of LTC system implementation in village health volunteers was evaluated in terms of real case usability demonstration.

Keywords: Long term care, digital innovation, smart sensors and technology, health monitoring, IoT

1 INTRODUCTION

Every sector in Thailand is now focusing on preventive healthcare [1] due to the rapid increase in the number of aged populations more than 30% by 2035 [2]. The majority of aging population has been unpredictably risk from their age-related disorder [3]. Together with the small propotion of elderly and caregivers currently decrease and not enough for elderly need [4]. Moreover, most of elderly prefer to stay in their homes rather than enter a healthcare institution when they need specialized care [5]. However, burden and costs of elderly care not only rise in the healthcare system but also for informal caregivers [6]. In the near future, there will be a shortage of caregivers [7], including overpopulation need in medical service if there is not enough management and preparation for complete aging society [8]. Here, we propose the pilot project and smart solution of Long Term Care Digital Innovation Platform for healthy aging society with automatically recorded people health data. In order to being closely monitored health status and immediately predict the risk of each age-related disorder via the LTC cloud and connectivity system. People's health status will be real-time monitored and shown on LTC app on their smart phone when they just scan the QR code on their individual smart card.

2 LONG TERM CARE SOLUTION

2.1 Long Term Care Digital Innovation platform

Overall architecture of Long Term Care (LTC) Digital Innovation platform is shown in Fig. 1.

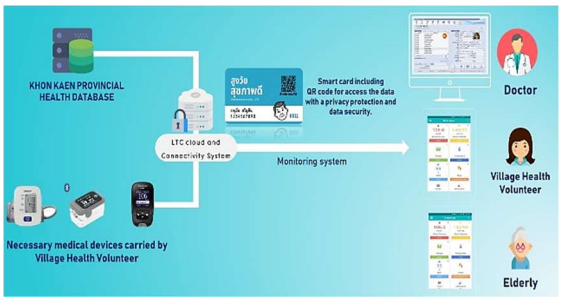

Figure 1: Overiew architecture of LTC Digital Innovation platform

The Long Term Care Digital Innovation Project (LTC) Platform consists of the following components: Khon Kaen Provincial Health Database, Necessary medical devices, LTC cloud and connectivity system and smart card including QR code for access the data.

The first part of this LTC platform is Khon Kaen Provincial Health Database which collect all basic and important information of 17,000 elderly in the Health Data Center (HDC) from Khon Kaen Provincial Health Office. All data were automatically imported into the LTC cloud and connectivity system of this platform and also connect online with various medical devices (blood pressure monitor, glucose meter, oxymeter, and electronic salinity) with immediately visual results on the screen via the LTC app. The second part is necessary medical devices carried by village health volunteer. The devices used in this system can sync with Bluetooth that can collect health data automatically through the LTC cloud. This LTC cloud and connectivity system will conveniently help the caregivers and village health volunteers continuously monitor elderly's health in real time monitoring. The third important part is LTC cloud and conncetivity system. This part will importantly sync all data from Health Data Center and collected health monitoring data from four medical devices carried by village health volunteers. All data were collected in the LTC cloud and being ready for showing on doctor screen or LTC app via smart phone or tablet of caregivers or elderly after the QR code on smart card was scanned and allowed to access the individual data. The last necessary part is called monitoring system which has the smart card including QR code for access the data with a privacy protection and data security. This smart card acts as the center point to sync all collected health data of elderly to the doctor screen or show on LTC app.

2.2 Necessary medical devices functionalities

Various medical devices were used and carried by village health volunteer were shown in fig. 2. Four medical devices are chosen to use used in this project namely, blood pressure monitor, glucose meter, oxymeter and electric salinity. The devices used in this system are able to sync with Bluetooth that can collect health data automatically through the LTC cloud. This LTC cloud and connectivity system will conveniently help the caregivers and village health volunteers

continuously monitor elderly's health with no need to record health information on the book. This system will help to provide the accurate and quick health information, reduce data errors and also help to facilitate the work of caregivers and village health volunteers.

The first device is blood pressure monitor (Model: HEM9200T) which is the tool used by wearing a pressure gauge on the left arm, placing the receiver in the middle of the inner arm of the upper arm about 2-3 cm, then press the button to start working. The data transfer tool will automatically show the pressure value on the screen. The second one is glucose meter (Model: Guide) which the test strips are installed on the glucose meter. To test the blood, using the lancing device puncture the fingertips, then barely touch the blood on the fingertips at the test strips area. The tool will automatically display the current glucose value on the screen. The third one which will help to measure the oxygen saturation in the blood is Pulse oxymeter (Model: BM1000B) used by inserting any fingertip in the oxygen meter and then press the measurement button. The device will transfer data and display on the screen automatically. The last important one helps measure the salty level in every meal of the day is electronic salinity (Model: SALT Index Tester: SIT-2) used in water-content food by dipping the tools into the meal you eat. The tool will display the salinity levels with various color bands (red is the most salty and yellow is the least salty). All collected data from necessary medical devices carried by village health volunteer were automatically synced to LTC cloud and connectivity system. All health monitoring report will be able to show on doctor screen or LTC app on smart phone or tablet when the QR code on the smart card was scanned and allowed to access the data with a privacy protection and data security.

Figure 2: Necessary medical devices carried by village health volunteers; blood pressure monitor (top left), glucose meter (top right), oxymeter (bottom left), and electronic salinity (bottom right).

2.3 Smart card including QR code for access the individually elderly health data

Smart card or healthy elderly card is shown in fig. 3 This smart card is designed for the 17,000 elderly who are above 60 and live domicile address in the Khon Kaen municipality. This smart card will facilitate the elderly when they go to hospital. The caregivers will scan the QR code on their smart card. Each QR code on each smart card will be unique for individual elderly. All basic health information will automatically sync to the system and immediately know the individual health information. This smart card is also synced to LTC app. The elderly must scan QR code on their smart card before open the LTC app on their smart phone. The advantages of this smart card are to reduce the redundancy in filling elderly information into the system, reduce individual information errors, even better for the physicians and caregivers can access the medical treatment records. This useful platform makes the work of the caregivers more easily, convenient and fast.

Figure 3: Smart card with unique QR code for individual elderly; front view (top), back view (bottom).

3 IMPLEMENTATION

3.1 Long Term Care Digital Innovation implementation

The system has been implemented and tested in Khon Kaen Municipality, Khon Kaen province. Basic health information of 17,000 elderly in the Health Data Center (HDC) from the Khon Kaen Provincial Health Office were automatically imported into the cloud system of this platform and also connect online with various medical sensor tools (blood pressure monitor, glucose meter, pulse oxymeter, and electronic salinity) with immediately visual results on the screen via the LTC app. The real demonstrated cases and app setting is shown in fig. 4 The elderly health database was developed for each individual health which can connect and exchange health information by scanning the QR code on the individual smart card as a data link. The application was then designed and developed to be able to use in all relevant sectors. For health monitoring purpose, all monitored health data of the group of volunteers were analyzed in order to predict the risks or for health prevention more efficiently.

Figure 4: Real demonstrated cases and overview app setting

3.2 LTC application implementation

The purpose of LTC application demonstration pilot was held for training and teaching how to use an application and related medical devices for the health volunteers in Sam Liam community health centers in Khon Kaen Province. Our motive is to create efficient health data collection systems and instant health reports for the elderly care which will lead to the creation of a model "Healthy City" for the population in Khon Kaen.

The volunteers were 10 elderly (n=10). They were 20% male and 80% female. Average education level was Bachelor's for 30%, high school and vocational certificate 30%, diploma 20% and lower than high school for 20%. Average ages were 41-50 40%, above 51 40% and in the range of 31-40 20%.

For satisfactory evaluation, we found that the volunteers were more satisfied after being demonstrated and trained by technician for using the application (Table 1). The average level of satisfactory after being demonstrated how to use the app was 3.54±0.85. In overall, the volunteers felt moderate with the usage of this LTC application.

Table 1: Satisfactory evaluation of LTC application usage (Scale 1-5 as least to most)

List	After use		
	$\bar{x}$	S.D.	Results
1. Desire to use this system often	3.50	0.70	Moderate
2. App system is not too complicate	3.50	0.70	Moderate
3. Easy to use	3.30	0.94	Moderate
4. Need instruction help from technician before use	3.40	1.07	Moderate
5. Various functions are well integrated	3.90	0.73	High
6. App is very inconsistent	3.80	0.91	High
7. The instruction leaflet is easy to follow	3.80	0.63	High
8. the system is complicated for use	3.70	0.94	High
9. Feel confident when using this application	3.50	0.85	Moderate
10. Self-learning before better use this system	3.00	1.05	Moderate
Total	3.54	0.85	Moderate

4 CONCLUSIONS

We present the real demonstrated cases and all useful data on LTC app setting. This digital innovation platform aims to create smart, efficient health data collection system and create instant health reports which will lead to the model of "Healthy City" for Thai people in case of long term healthcare.

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Understanding Cultural Differences between Thai and United States Postgraduate Students.

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Abstract: The study aimed (a) to explore the cultural differences between Thai and the United States postgraduate students during the exchange programs, and (b) to identify the key success factors of becoming a global citizen. The population consisted of 88 doctoral students who had joined the exchange program between Phranakhon Rajabhat University (PNRU) and the University of Missouri St-Louis (UMSL) during 2013 to 2018. The sample were 20 volunteering doctoral students who had singed the consent forms on their willingness and their time available to participate in this research. The qualitative research had been adopted to collect the data through in-depth interviews, focus groups and observation. The data had been analyzed by using content analysis and coding techniques to create the themes and compare them with each other's sources of data through a triangulation technique. The results revealed that (a) the most important aspects of cultural differences based on the Hofstede Model between Thai and the United States doctoral students are Individualism and Collectivism and (b) the key success factors of becoming a global citizens consisted of two skills (English language and Information Communication Technology; ICT skills) and one knowledge on cross-cultural awareness. Postgraduate students who had adopted those skills and knowledge have resulted in interconnectedness between people as well as between the local and the global environments.

Keywords: Cross-Culture, Hofstede Model, Global Citizenship, Thailand, United States

1 INTRODUCTION

More than a decade of exchange programs between PNRU and UMSL has created the strong relationships among doctoral students and academic staff. However, before they participated in this program, students and staff both from UMSL and PNRU had reported some difficulties and perceived this program as a waste of time. This research aimed to find out what kind of difficulties had prevented them from participating in this exchange program. How to support them to gain those experiences and prepare themselves to be a part of the global citizenship.

This is a good opportunity for PNRU and UMSL who has developed an MOU since 2009 to review their problems and preparing their exchange programs between doctoral students and academic staff to be more fruitful especially, to increase the collaborative research between the two universities. This research had been funded by the PNRU and working closely with UMSL to collect the data. Without the dedication of the participants between both universities, this research will not be completed.

2 RESEARCH OBJECTIVES

The research aimed; (a) to explore the cultural differences between Thai and the United States postgraduate students during the exchange programs, and (b) to identify the key success factors of becoming a global citizen.

These two objectives became the main focus because in the pilot study of what are the difficulties to prevent them to participate in the international exchange program, it was found that the cultural differences are the major concern and the lack of English proficiency are the critical problem. Then this research had been focused on what are the cultural differences that caused the problem of collaborations between Thai students and those of the United States? Moreover, what are the key success factors of becoming a global citizen? When considering about global citizenship, it is based on the explanation of Bosio (2019, p.1) who suggests that "global citizenship is a figurative idea that can coexist with national citizenship, a state of mind, a feeling of belonging, and attitude, a set of dispositions and practices that carry an important responsibility: to do good for the entire human community."

The results of this research have been providing the key success factors of becoming the global citizen. It is necessary for the university to prepare students and staff to be a part of the global citizenship (Cotton, Morrison, Magne, Payne & Heffernan, 2019; O' Connell, 2014). Nowadays, people who are living in any parts of the world can be part of each other's lives by working together or sharing and helping each other (Drath et al., 2008; Martin, 2007; Uhl-Bien, Marion & McKelvey, 2007). The geographical distance is not a problem (Allen, 2020). Where the new technology can make everyone connecting easily (McKeown, Vedan, Traplin, Sanford & Bourne, 2020). The major reasons that we cannot collaborate and create a wonderful piece of work is because we do not understand each other's cultures and we create the wrong attitude towards people who are differences from us (Bishop & Robinson, 1998; Condon & Yousef, 1975). It is showing that the more we learnt about cross cultural differences the better understanding on global citizenship we become (Bosio, 2019; Chan, 2010; Davies & Danahher, 2014; Foley & Kaiser, 2013; Goodier, Duffy & Goodman, 2020. Kasworm, 2012; Wahlgren & Geiger, 2011).

3 REVIEW OF LITERATURE

The concept of cultural differences is based on the research results of Hofstede Model (Hofstede, 2011; Minkov, 2018) which recommended that there are six dimensions of national cultures: Power Distance, Uncertainty Avoidance, Individualism versus Collectivism, Masculinity versus Femininity, Long versus Short-Term Orientation, and Indulgence versus Restraint. Those six dimensions of national cultures have been implemented to analyse the data from this research. However, when asking about the cultures it can be defined in many ways (Eid & Diener, 2009), for this research, the researcher had provided the definition of culture as the ways we do things around here. When asking about Thai culture, it refers to the way Thai people do things in Thailand and when questioning about American cultures, it means the way American people perform regular daytime activities in the United States.

Hofstede (2011, p. 3) suggests that "culture is the collective programming of the mind that distinguishes the members of one group or category of people from others", which is similar to Hall (1976) who had divided cultures according to their ways of communicating into high-context and low context cultures. Moreover, when considering about others work, such as Talcott Parsons and Edward Shils (1951), Florence Kluckhohn and Fred Strodtbeck (1961),

who were the famous United States anthropologists that had explained about cultures into the similar definitions. It is obvious that human action is both differences and similarities. It is depended on the "pattern variables, choices between pairs of alternatives" (Parsons & Shils, 1951, p. 77). Mary Douglas (1973) proposed the model of the two-dimensional ordering of ways of looking at the world; firstly, is group or inclusion and secondly, is grid or classification. The two-dimensional ordering is similar to the Individualism versus Collectivism of Hofstede Model (Hofstede, 2011).

In the 2000s, research by Minkov (2007) using the data from the World Values Survey had found more cultural dimensions and developed them with Hofstede to become the six dimensions (Hofstede, Hofstede & Minkov, 2010), which have been used in this research.

It is obvious that there are many models to explain the cultural differences (Hofstede, 1996; 2001; Kim, Smith, Dugan, Trompenaars, 1996; Triandis, 2001; 2004; Triandis, Kagitcibasi, Choi & Yoon, 1994; Trompenaars, 1993). Only the six dimensions of Hofstede Model have met with the most positive reactions amongst psychologists, especially in the United States (Hofstede, Hofstede & Minkov, 2010).

4 RESEARCH METHODOLOGY

A qualitative approach was used to explore questions of multicultural experience (Patton, 2002), examine the university's policies, strategic practices and process, understand the barriers to and facilitators of exchange program between PNRU and UMSL. This was adopted in order to understand the key success factors (or failure) of the international exchange program (Starks & Trinidad, 2007) and observe postgraduate student's behaviors to obtain the desired results. The population were 88 doctoral students who had joined the exchange programs between PNRU and UMSL during 2013 – 2018 following the ethics and institutional approvals from both universities. Invitations to participate in the research were sent via emails to 10 members of each former exchange postgraduate students from PNRU and UMSL. The process of selection was based on their academic experiences and/or positions that are relevant to cross-cultural experience programs and participants who had involved in international conference postgraduate research between the two universities. The invitations introduced the researcher and provided information about participant identification and recruitment. Copies of the research questions and the participant consent form were provided both at the PNRU in Bangkok, Thailand and at the UMSL in Missouri-St. Louis, the United States. All invited doctoral students expressed their willingness to participate in the in-depth interviews, focus groups and observations. While scheduling for the in-depth interviews and focus groups, the behavior observations had been conducted through the "Thai doctoral exchange program at the UMSL, St. Louis, the United States from April 25 – May 4, 2018." At the conclusion of the in-depth interviews (which were recorded with consent), the researcher was satisfied with the consistency of the data and no further interviews or focus groups or document analysis or observations were required (Patton, 2005). The transcriptions both in the Thai and English languages of the in-depth interviews and focus groups had been sent to all of the participants to re-check before analyzing the data. The data had been analyzed by using content analysis (Krippendorff, 2009) and coding techniques to create the themes and compared them with each other's sources through a triangulation technique (Hsieh & Shannon, 2005).

5 RESULTS AND DISCUSSION

There are two findings from this research. Firstly, the finding indicated that there are six cultural differences among Thai and United States postgraduate students during the exchange programs which are similar to the Hofstede Model of dimensional cultures (Hofstede, 1980a; 1980b; 1991; 2001a; 2001b; 2011; Hofstede, Hofstede & Minkov, 2005). The six cultural differences among Thai and United States postgraduate students are labelled as follows: Hierarchy, Obedient, Harmony, Father's Rules, Compromise, and Destiny. It can be explained that for Thai students they mostly believe in the hierarchy and respect people who have higher social status (Pimpa, 2012). For example, Thai students pay respect to elderly people or people who have higher positions, such as their teachers or employers. While the U.S. students would argue with elderly people if they believe that they are right and they will listen to the reasons of those people more than their higher social status or positions (Schermerhorn & Harris Bond, 1997). The results show that most of the Thai students have the same behavior when they participate with others in the classrooms or in the public, such as showing the obedient behavior to

others, especially people who have more experiences or the leaders of the groups and they seems to be harmonies towards the group and agree with others when they have to present their idea (Yukongdi, 2010). It is common for Thai students to be a part of the group (Sayruamyat, & Nadee, 2020). They want to feel the sense of belonging and maintain their strong relationship with the group (Onyusheva, Thammashote & Thongaim, 2020) more than showing any idea differences (Graham, 2019).

When considering about the rules of the father, it can be seen that the Thai father is the center of the house. A father has the role to protect everyone in the family and looking after his wife and children (Chunuan, Vanaleesin, Morkruengsai & Thitimapong, 2007). It is understanding why Thai students will respect and follow the Father's Rules (Pornrungroj, 1993; Siengthai & Leelakulthanit, 1993). For boys and girls, they both learn about their different roles and responsibilities since they were young (Tantiwiramanond & Pandey, 1987). It is obvious that boys should play sports, like boxing and football, while girls should spend time with their dolls (Davies & Deckert, 2019). Arguing with the father is not an acceptable manner, and good children and a good wife should be respectful to their father and husband (Hughes, 2011; Vichit-Vadakan, 2008.). Compromise and Destiny can be seen everywhere in Thai culture (Stamolampros, Dousios, Korfiatis & Symitsi, 2020). Most Thai students believe that if they will be a successful person in the future, there will be no matter what they are doing, as it is a destiny (Gehrels & Gehrels, 2019). Their destiny means everything to them. It will be used to explain why someone can be very successful and why another cannot achieve anything. This is expected because they believe that their destiny has been written for them. As far as they are aware, their future cannot change (Jenkins, Shresthova & Peters-Lazaro, 2020). When Thai students want to do something, they will do in the moderate way; they compromise things and they do not risk everything to achieve their goals. Because part of them believe that destiny is controlling their lives and they will keep everything in the compromise way (Thovuttikul, Ohmoto & Nishida, 2019). The six cultural factors above between Thai and the United States students are very different (Wells et al., 2019). The data from the in-depth interviews showing the frustration of PNRU and UMSL students among those six behaviors and believe, when they have to collaboratively work with Thai students, that they do not understand why Thai students do not present any opinions that are different from themselves (Schermerhorn & Harris Bond, 1997). They do not understand why Thai students believe in the destiny and depend on their luck more than their own hands (Suwannarat, 2019). They do not understand why Thai student always want to ask teachers more than find out their own answers. They do not understand why Thai students depend on the decisions of their friends and their families more than themselves (Benson & Filippaios, 2019). Moreover, they do not understand why men and women are not showing the equal roles and responsibilities. Those frustrations can be explained by the cultural differences. It is similar to the research of Hofstede (2011) and Minkov (2011), which identifies the national cultures to be six dimensions. Each of them can be found in this research as follows;

Hierarchy can be classified as large Power Distance because Hofstede (2011) suggests that power distance related to the different solutions to the basic problem of human inequality. The results from Hofstede (2011) said that the United States has 40 scores and Thai has 64 scores on Power Distance. It is showing that Thai people have a larger Power Distance than the United States people. Which are similar to the results from PNRU and UMSL students. For PNRU students who come from the large Power Distance, they believe that parents have the roles to teach children and children have the roles to pay obedience. It is the same concept of Hierarchy. For UMSL students who have less Power Distance they believe that parents and children should be treated as equals (House & Pinyuchon,1998). Children should be consulted by their parents, but they can make their own decisions and parents should give them the freedom to take their own responsibilities (Hallinger & Kantamara, 2000).

Obedient can be classified as strong Uncertainty Avoidance, because Hofstede (2011) suggests that Uncertainty Avoidance related to the level of stress in a society in the face of an unknown future. The results from Hofstede (2011) said that the United States has 46 scores and Thai has 64 scores on Uncertainty Avoidance. It is showing that Thai people has stronger Uncertainty Avoidance than the residence of the United States. These are similar to the results collected from both the PNRU and UMSL students. For PNRU students who come from the strong Uncertainty Avoidance background, they believe that teachers are supposed to have all the answers and citizens feel and are seen as incompetent towards authorities. It is the same concept of Obedient. For UMSL

students who have weak Uncertainty Avoidance they believe that a teacher may say "I don't know" and citizens feel and are seen as competent according to authorities. They feel comfortable with ambiguity and chaos. UMSL said that changing their jobs and moving their homes to live in any foreign countries are not a problem at all if this is what they want to do (Bozer & Delegach, 2019).

Harmony can be classified as Collectivism because Hofstede (2011) suggests that Individualism versus Collectivism related to the integration of individuals into primary groups. The results from Hofstede (2011) said that the United States has 91 scores and Thai has 20 scores on Individualism. It is showing that Thai people are Collectivism while the United States people are Individualism. This results from Hofstede (2011) confirms the behaviour among PNRU and UMSL students during their exchange programs. Most of the problems and conflict between them came from the misunderstanding of Individualism versus Collectivism (Kuo, 2013). The data from the in-depth interviews show that PNRU students feel uncomfortable (Hughes & Thomas, 2005) when they have to answer some specific questions about their meals. For example, how many prawns do you want? What would you like to drink? How much soup do you need? Do you want more? Those kinds of questions are disturbing to them. This is observed in the in-depth interviews below.

> *... I don't see any point in answering all of these questions. If you want to host us, you should know and understand how much or how many we would like to eat. It was really annoying to keep answering all these silly questions. I don't want to have dinner with them. I know they want to provide us the best meal, but it was too annoying. If they want us to eat or drink just bring them on the table. If we like them, we will eat them. If we don't like them, we just don't touch them. That's all, no problem...(Male, KT)*

The research found that the major reasons behind why those upset feelings of PNRU students were experienced while they were staying with UMSL students in the United States was because they are more likely to be like the others (Hook, Worthington & Utsey, 2009). They felt uncomfortable to say or choose anything that will make them different from the group (Parkes, Bochner & Schneider, 2001). Especially at the dinner table, PNRU students wanted to act like others at the table. They find it difficult to just make individual decisions like this for themselves. If the host or others had prepared any kind of meals for them, they would agree to eat that food. They are concerned about the group more than themselves. However, for the UMSL students who believed in Individualism, they are expected to be self-reliant and display initiative (Callister & Wall, 2004). They want to make sure that everyone is getting what they want. The example of the in-depth interviews from UMSL is as follows:

> *...When we had invited PNRU students to have dinner at our home. I wasn't sure that our cooking and our meals would suit them. I was worried that they could not eat our meals or maybe they might want something else. However, the more I kept asking them, the less they answered. Mostly just smile to us. But we did not understand what do you want? Why don't you speak out for yourself? Maybe they were so shy. But there was nothing to be shy about. I am worried to invite them to have a meal at our home again. Because they seem like they don't want to say anything about food or say what they really want. It is difficult to guess. I have no idea how to make them feel relaxed. Smiling meant nothing for us. They should say directly what they would like and then we would understand. (Female, CS)*

The results from Hofstede (2011) said that American culture is supposed to take care of him-or-herself and his or her immediate family only, which are opposite from that of Thai culture. Most Thai people are born into extended families or clans which protect them in exchange for loyalty. The cultural differences among PNRU and UMSL students on this issue can be seen during the exchange programs and most of everyone who gave the interviews felt the same problems existed.

Father's Rules can be classified as Masculinity because Hofstede (2011) suggests that Masculinity versus Femininity related to the division of emotional roles between men and women. The results from Hofstede (2011) said that the United States has 62 scores and Thai has 34 scores on Masculinity versus Femininity. It is showing that Thai and United States people are more likely to favor towards the Masculinity society, but the United States are higher (Chapman & Hendler, 1999; Savran, 1998). This indicates from the results that the UMSL students have been driven by competition, achievement and success more than PNRU students (Kusz, 2020).

Compromise can be classified as Long-Term Orientation because Hofstede (2011) suggests that Long-Term versus Short-Term Orientation related to the choice of focus for people's efforts: the future or the present and past. The results from Hofstede (2011) said that the United States has 26 scores and Thai has 32 scores on Long-Term versus Short-Term Orientation. It can be seen that PNRU and UMSL students are not much different in this issue. Although, UMSL students have lower scores than PNRU students, but in this research both of them are focus on traditions and adapt to the circumstances. In many situations, it was found that PNRU students have more compromise than UMSL students, such as when choosing between what is good and evil.

Destiny can be classified as Restraint because Hofstede (2011) suggests that Indulgence versus Restraint related to the gratification versus control of basic human desires related to enjoying life. The results from Hofstede (2011) said that the United States has 68 scores and Thai has 45 scores on Indulgence versus Restraint. It means that the United States scores as an Indulgent society (Gilboa & Mitchell, 2020). This is reflected by the data from the in-depth interviews, where the UMSL students mostly were saying that they are working hard but play harder. While comparing with PNRU students who are believing in the moderate way. They will not take higher risk for the higher return. Their daily lives will be more likely to follow the society norms and obey the laws more than UMSL students. It is not surprised that UMSL students are more actively involved in sports and higher percentages of obese people than PNRU (Serdyukov, 2020). Table 1 below has shown the differences and similarities of PNRU and UMSL cultures and the scores of each country.

Table 1: Cultural differences compare with Hofstede's national cultures.

Cultural Differences	Hofstede's Model	PNRU	UMSL
Hierarchy	Power Distance	64	40
Obedient	Uncertainty Avoidance	64	46
Harmony	Individualism or Collectivism	20	91
Father's Rules	Masculinity or Femininity	34	62
Compromise	Long Term or	32	26
Destiny	Short Term Orientation Indulgence or Restraint	45	68

From Table 1, it can be seen when following the concept of Hofstede (2011), that the biggest cultural difference between PNRU and UMSL is under the Harmony category. This also can be identified as Individualism versus Collectivism, which is similar to the results from this research. Most of PNRU and UMSL students have the same problems to understand each other's cultures on this issue more than the rest of the cultural dimensions.

The second finding from this research found that the key success factors of becoming a global citizen consisted of two skills which are English language and Information Communication Technology; (ICT) skills. Both skills have been identified as the important qualifications for a global citizenship (Bencze & Carter, 2011; Esquith, 2007; Gretter & Yadav, 2016; Hammond & Keating, 2018; Inglehart, 2018; Zubiaga, Procter & Maple, 2018). For PNRU students they said that without the English and ICT skills, it is impossible for them to participate in the exchange program with UMSL students (Thongprasert, 2012). Both English and ICT are the skills to survive in the 21st century, and they are most recommended to everyone who want to participate in the exchange program or becoming a global citizen to practice both skills so to reach to the point that they can create the best opportunity for their career and professional development. The importance of the English language can be seen as the gate to open to every knowledge and contact to everyone around the world (Vogt, 2020). As the English language has become the common language for every country (Moen, Rialp & Rialp, 2020), it is not surprising that students who have better English language skills always have better opportunities to become a global citizen (Wong, 2020). For the meaning of ICT skills in this study, it means the everyday usage of digital technology, which includes when using a computer, tablet or mobile phone, send email, browse the internet, make a video call - these are all examples of using basic ICT skills and technology to communicate (Chung, Yoo, Kim, Lee, & Zeidler, 2016)

Although the English language and ICT skills are very important, the knowledge about cross-cultural awareness is also necessary to understand before going abroad (Smith, 2020).

Especially for students who want to create the good collaborative work environment and strong relationships with multinational countries (Wu & Marek, 2020). The data from this research confirmed that students who had studied cross-cultural awareness and cultural differences between Thai and the United States before joint the exchange programs had less problems than students who did not hold awareness with the existing of cultural differences. One of the data from focus groups showing that students who have learnt about cross-cultural awareness are more likely to appreciate the multinational relationships and believe that those relationships have created more opportunities for them to be a part of the global citizenship as one of the participants said that:

> *...if I have friends who live in my country I might have a hundred of friends who have the same background, knowledge and lifestyles, and we do not need to feel surprised by each other behaviours but if I have friends who came from other countries I will learn more than my imaginations and my life will be more exciting. I love to give myself more chance and open my heart to the world out there...(Male, ST)*

The advantages of being a global citizen are not only having more opportunities for their careers and professional development, but also increasing the understanding of peace and human rights, respect for diversity and tolerance and inclusiveness and widening the concept of their obligations to all humanity.

6 CONCLUSIONS

The aimed of this study was to explore the cultural differences between PNRU and UMSL postgraduate students during the exchange programs. The results revealed that there are six differences that can be seen from among all of the participants which can be anlaysed as followed: (1) The different scores of the Hierarchy or the Power Distance between the Thai and the United States students. (2) The Obedient or the Uncertainty Avoidance that are so obvious of Thai students more than those of the United States. (3) The Harmony or the Individualism versus Collectivism of Thai and the United States students which can be seen as the most important of these differences in culture amongst them. Many participants said that these different behaviours among them had caused a lot of misunderstandings and it is necessary to take time to explain and learn from each other's perspectives to maintain the strong relationship in the future. (4) The Father's Rules or the Masculinity versus Femininity, which are focusing on the roles of men and women in the society. This cultural differences among PNRU and UMSL are not so obvious and the data from the focus groups showed that both PNRU and UMSL have similar attitude towards the roles of men and women, which is different from the Hofstede's Model. It can be explained that because UMSL is located in the Missouri St.-Louis and this area of the United States is more religious than other parts of the country. (5) The Compromise or Long-Term versus Short-Term Orientation, there is not much of a difference among PNRU and UMSL. However, in Thai society it seems to have more compromise than in the U.S.A. society. Finally, (6) the Destiny or the Indulgence versus Restraint, which has shown that UMSL students have more Indulgence than PNRU students. In another word it can say that PNRU students believe in the Destiny to control their lives more than controlling themselves. Most of them believe that their achievement or their failure are depending on their own destiny. They will not be too upset if anything does not happen as they had expected. Part of them believe that it had already been written by their Destiny.

The key success factors of becoming a global citizen consisted of two skills and one knowledge. Firstly, the English language skills, which are a very common language to use everywhere in the world and secondly, the ICT skills or the Information Communication Technology which means the everyday usage of digital technology such as computer, tablet or mobile phone to communicate. Thirdly, the one important knowledge to become a global citizen is the cross-cultural awareness (Bosio, 2018; 2020), which means the knowledge to understand and accept the possibility of different cultures in the world. A belief in the multicultural respect with a view that everyone should become socialised into living successfully in a global society. As Bosio (2019, p. 3) said that universities should develop "the wisdom to recognise the interconnectedness of all human lives, the courage to attempt to comprehend people of difference walks of life and the compassion to maintain a creative empathy that reaches beyond one's immediate contexts". The results of this study should be added to every curriculum in higher education to prepare both graduate and postgraduate students to become a part of global citizenship.

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Green Edible Building Facades Potential for Energy Saving

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Abstract: Urban- and vertical farming is gaining popularity as a sustainable and food secure agricultural approach. Food, Water and Energy is essential for human wellbeing, world peace and sustainable development. Global population growth and urbanization has become a major challenge, therefore sustainable transformation of urban areas has become a tactical adaptation and mitigation strategy in many cities such as, Paris and Singapore. Public- and private operations have demonstrated financial and social benefits of Urban Farms and their scalability properties. Studies have confirmed that vertical greenery wall systems function as an insulator for buildings and at the same time have a cooling effect on tropical urban areas. In this research we are testing the insulating effects by covering walls and rooftops with agricultural food production systems. We are testing 1) the vertical Bamboo - Ponics system (developed by Lea Pedersen at SGtech) and 2) simulate a rooftop garden using 35cm of soil to grow Chinese morning glory, both food producing systems had a great effect on the OTTV (Overall Thermal Transfer Value). The study faced some errors but provides a clear clear indicator that sustainable agriculture and energy saving can be combined with multiple economical and environmentally friendly returns.

Keywords: Vertical wall food farms, Energy saving Buildings, Climate resilient Home and community.

1 INTRODUCTION

In May 2019 Lea Pedersen begang the development of a smart farm concept in collaboration with SGtech. This project was established from sharing concerns about future conditions for agriculture and human wellbeing with increasing global temperatures.

Figure 1: Bamboo-ponics prototype.

The Smart Farm Project got attention from students, who requested for an internship opportunity doing research on the hypotheses to saving energy in buildings employing agriculture green facade and financial analysis of the smart farm Bamboo-Ponics. The hypothesis is to build a vertical farm in front of a wall that is exposed to several hours of sunlight. When the heat from the sun touches the surface of a wall, it transfers into the wall and heat up the room. Because of the closely placed bamboo pipes and plants, most of the wall is covered by shadow the whole day. We will examine how the vertical farming reduces the heat being transferred. This R&D project aims to demonstrate multiple benefits from employing building facades (walls and rooftops) to urban smart farming. Those benefits can motivate private- and public projects to involve smart farming in future projects and thereby increase sustainable agriculture.

In 2015 the majority of countries around the world signed the Paris Agreement on Climate Change, by pledging to keep global temperatures well below 2°C pre-industrial levels targeting 1.5°C. The IPCC Special report "Global Warming of 1.5°C" estimated that the world has a remaining carbon budget of 420 Gt CO_2 for a 66% change, to stay below 1.5°C starting from 1st of January 2018. (Safikhani, Abdullah, Ossen, Baharvand, 2014) Global emissions are approximately 42 Gt CO_2 per year, and if it remains unchanged during the next 10 years, we will globally face a 1.5°C increase. In 2019 the world witnessed a continued increase in CO_2 emissions (Cazanave, and other, 2019).

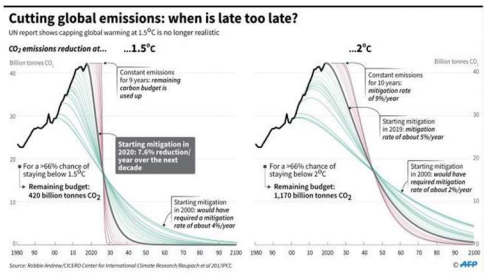

Figure 2: Possible scenarios for decreasing global emissions.

The most essential resources for survival are food and water, which already has real-time problems with only 1°C increase from pre-industrial levels, therefore, the agricultural industry is facing large challenges in the coming decades.

IPCC SRCCL Report stated (Jackson, R., and other, 2018): *"With these warmer temperatures (with changing precipitation patterns) have altered the start and end of growing seasons, contributed to regional crop yield reductions, reduced freshwater availability, and put biodiversity under further stress."*

Global projections indicate that the demand for energy, food and water will increase over the coming decades, due to growing populations and economic growth in developing countries (FAO, 2014). According to NASA, 21 of the planet's 37 largest groundwater storages have exceeded sustainability and are being depleted, while 13 are considered significantly distressed, threatening regional water security and resilience. The World Economic Forum put Climate Change as a part of all the top five risks facing humanity in 2020.

Over the last few decades, vertical farms have proved beneficial for feeding urban citizens by multiple successful operations worldwide, and in the coming decades the importance of innovative food systems will be essential to meet the demands of 10 billion people, where 70% of them are predicted to live in cities, giving the cities 7 billion people to feed (World Economic Forum, 2020). Green walls and rooftops have a mitigating effect on Urban Heat Islands (UHI) which are getting attention as cooling strategies in tropical cities. (Price, Jones, Jefferson, 2015)

Objectives in this study are to examine if buildings in tropical environments can acquire insulating effects from green edible walls and rooftops, by decreasing the absorption and storage of thermal heat.

What is vertical farming?

The concept of vertical farming was invented in a project about self-sufficient cities at Columbia University, by Professor Dickson Despommier and his students. It was clear that it would be impossible to grow sufficient amounts of food "horizontally" in cities, therefore, they came up with the idea of growing in layers, which changed the global picture of big farming within city boundaries. Today there are multiple huge operations around the world, especially the US, where AERO farms produce 120 times more food per acre than traditional agriculture. Singapore has used this approach as part of their solution to feed their citizens, because they are a small country with limited land for farming. The French government aims to cover 100 hectares of the city's rooftops, walls and urban spaces with plants by the end of 2020, with one-third of it being dedicated to agriculture.

Vertical Bamboo-ponics farm

The vertical farm development at SGtech, will reduce the environmental costs of plastic used in hydroponics and vertical farming by employing Bamboo instead PVC, which is highly renewable due to its high carbon sequestration ability and 35% higher production of oxygen. Named as the fastest growing plant in the world, it is one of the best crops for rapid actions in terms of sequestering carbon from the atmosphere that provides a simple and fast option for mitigation. Looking exclusively at carbon footprints, neglects other important issues like water usage, so in this method of farming, we recycle and reuse the water, which in similar systems reduces usage by 90-95%.

The farming approaches are Hydroponics and/or Aquaponics, cultivating vegetables without soil, growing vertically inside hollow bamboo, with flowing water, which is being absorbed by the plant's roots, then recycled back to the tank. Numerous research studies have declared that vertical farming offers sustainable strategies for future urbanization and Climate Change Impacts, with NO pesticides, harmful chemicals and GMOs, using less water than traditional agriculture, and 75 to 90% less space.

Rooftop Garden

The rooftop gardens 35 cm soil will increase the energy efficiency and provide space in urbanised areas for growing food. The benefit of insulating the rooftop is for the room below to be less affected by the sun and the outside temperature, which should lead to less energy use for air conditioning. The case of this study is to find the roof thermal transfer value efficiency reduction by using rooftop garden.

Figure 3: Bamboo-Ponics vertical farm and rooftop garden.

2 METHODS

Vertical bamboo farm

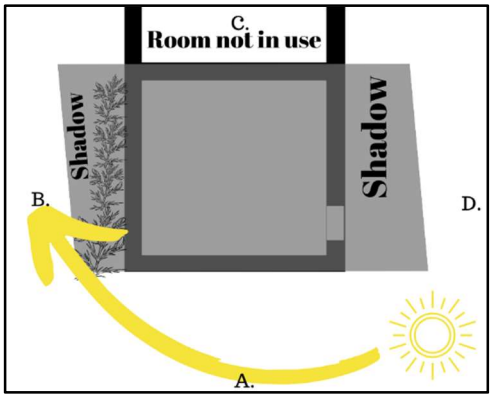

Figure 4: Outline of the test room.

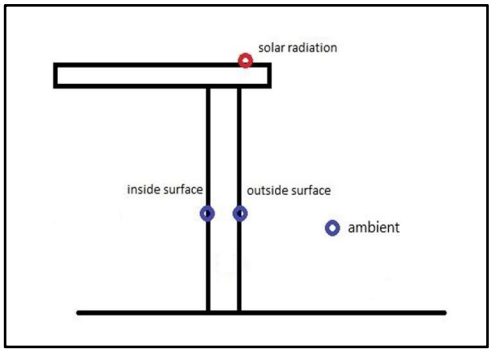

Figure 5: Arrangement of data points

The test wall (A) has been chosen so it is facing south getting sun almost throughout the whole day. The room's east and west side (B), (D) are shadowed by the roof and bushes while the north side (C) is connected to another room. There are three thermocouples (blue) installed at the room recording temperature data and one reference cell (red) recording solar radiation. The measuring points are arranged as in Figure: 4. Three points measuring temperature: 1. inside surface temperature of the wall; 2. outside surface temperature of the wall; 3. the ambient temperature. All the measuring points are applied in one line perpendicular to the wall.

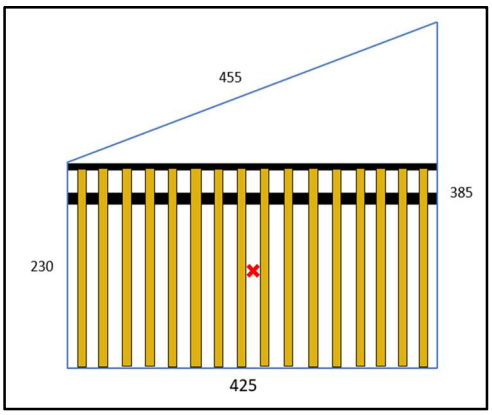

Figure 6: Front view of the test wall.

Solar radiation and ambient temperature are recorded for reference. There will be two cases of measuring. The first case is without the vertical Bamboo-Ponics farm for which data has been taken on 05.12.19. The second case is with the installed vertical farm. The data of this experiment is an average of three days from 26.01.20 to 28.01.20. It is important for the reference temperature and solar radiation to be as similar as possible on both days of measuring. This measurement is done without plants to show the least possible effect the farm brings to the heat transfer of the wall. Considering there will be times during a growing cycle without fully grown plants. Equipment: For data collection a Pico data logger, five thermocouples type K and a solar reference cell are used.

Rooftop garden

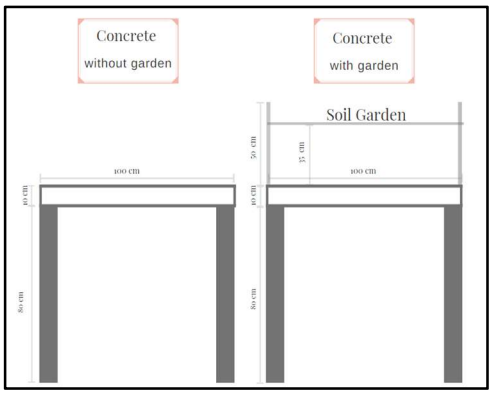

Figure 7: Setup of the rooftop garden experiment.

For the experiment there are two rooftop models out of concrete, each with an area of 2 m². The thickness of the roof concrete is 10cm. On one of the models there is a rooftop garden using 35cm of soil. In this case we planted Chinese morning glory into the farm. There are eight measuring points using thermocouples type K and one measuring point using a solar reference cell. The measuring points are arranged as shown in Figure: 8 (Tan, Chung Liang et al, 2017).

Solar radiation and environmental temperature are recorded for reference. There are two cases of data collection. One time without morning glory on 15.12.19 and one time with morning glory on 06.01.20 to see if the plants have any significant effect on the temperature (Leong, A., 2009).

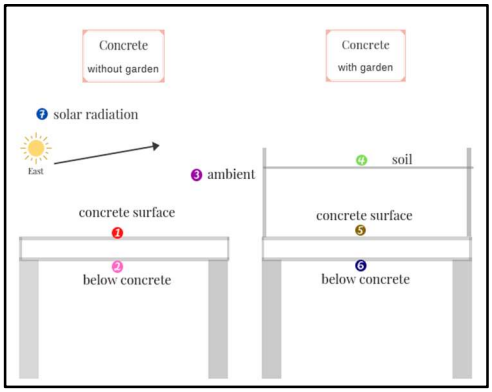

Figure 8: Data points of the rooftop garden experiment.

3 RESULTS

Vertical bamboo farm

An important factor for the walls' temperature is the solar radiation which is very

similar on both days of taking data. In terms of total exposure of solar radiation there is a difference of 8.8% (1400 kJ/m²).

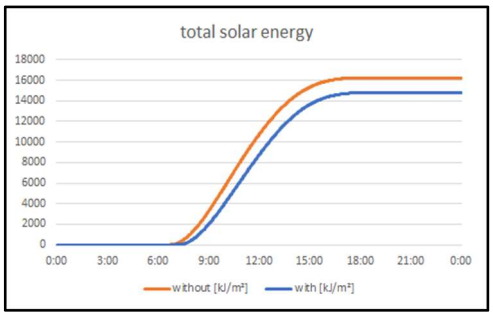

Figure 9: Reference of solar radiation.

To calculate the heat transfer of the wall it is important to measure the outside and inside surface temperature of the wall. The following charts compare the temperatures on the outside surface, the inside surface and the ambient temperature.

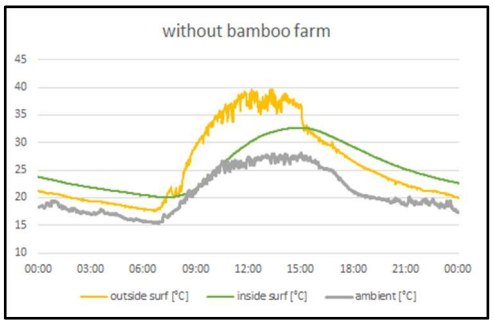

Figure 10: Results from experiment without farm.

Without the Bamboo-Ponics farm the temperature on the outside surface goes from 19.7°C at night up to 39.6°C in the time between 12:00 and 14:00. This leads to a temperature range of 19.9°C. At about 15:00 the rooftop is shadowing the wall leading to a breakdown in temperature. The temperature on the inside surface goes from 20.2°C in the morning up to 32.7°C in the afternoon leading to a temperature range of 12.5°C. Due to heat transfer the peak of the inside temperature is delayed to the outside surface and has less variation throughout the day.

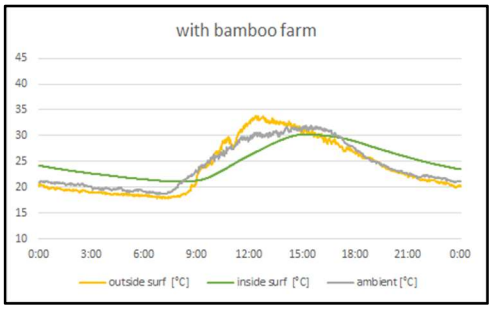

Figure 11: Results from experiment with farm.

With the Bamboo-Ponics farm all three temperatures are closer. The temperature on the outside surface has its minimum at 18.0°C and peaks at 33.8°C, which leads to a temperature increase of 15.8°C. Consequently, the temperature variation is 4.1°C lower with farm, decreasing it by 20.6%. It can be noticed that with farm the temperature peaks only for a short time while without farm the temperature stays at a high level for almost 3 hours. The temperature on the inside surface rises from 21.0°C to 30.2°C leading to a temperature range of 9.2°C. 3.3°C less than without farm decreasing it by 26.4%. To compare the heat transfer it is important to compare the OTTV (Leong, A., 2009) of the wall defined as

$$OTTV = \frac{(A_{w1})(OTTV_1)+(A_{w2})(OTTV_2)+\cdots+(A_{wi})(OTTV_{wi})}{A_{w1}+A_{w2}+\cdots+A_{wi}} \quad (1)$$

Since there is only one layer in the wall the OTTV can be calculated with a k-value of

$k = 0.326$ W/m·K

and the thickness of the wall of

$\Delta x = 11$ cm

and the following equation

$$OTTV = \frac{k}{\Delta x} \cdot \Delta T \quad (2)$$

Figure: 12 is showing the RTTV of both scenarios by minus and plus show direction of heat outflow and heat intake to the rooftop respectively. The OTTV can be significantly decreased by applying a Bamboo-Ponics farm in front of the wall.

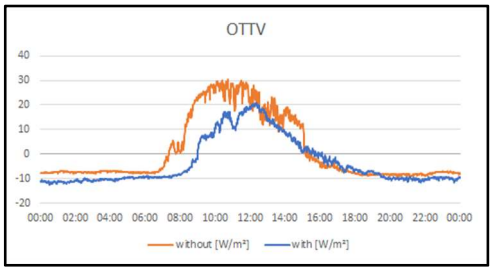

Figure 12: Comparing the OTTV of the experiment both with and without farm.

In the night time the OTTV is almost similar in both scenarios because there will be no radiation. This shows the enormous effect solar radiation has on the heat transfer through the wall. It also shows certainty to the data because at night time it should make no difference whether or not there is a bamboo farm applied to the wall. This means the OTTV should be almost identical at both nights. In this case the average difference in the time between 18:00 and 06:00 is 2.27 W/m². By integrating the data one can calculate the total heat flux showing the amount of energy transported into the room. During night time the room loses energy almost the same rate both with and without farm according to OTTV.

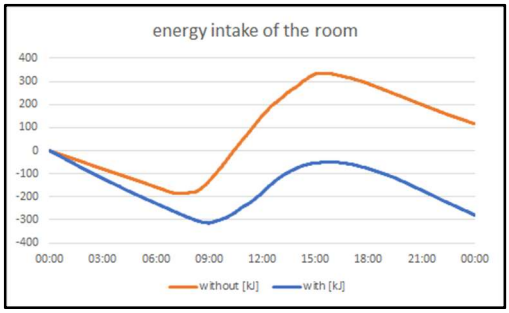

Figure 13: Comparing the energy intake of the room through the wall.

According to Figure: 13 with farm during the daytime and the early morning there is significantly less energy transported into the room. At the end of the day without a farm there is 115 kJ/m² transferred into the room. With farm the room loses 280 kJ/m² through its wall. This means 395 kJ/m² less energy transferred into the room only by covering 27% of the wall with bamboo pipes. This concludes to a reduction of 343.5% meaning summarised over the day with farm the wall actually transfers energy from inside to outside. Energy which is transferred into the room by the other walls, windows and doors.

Rooftop garden

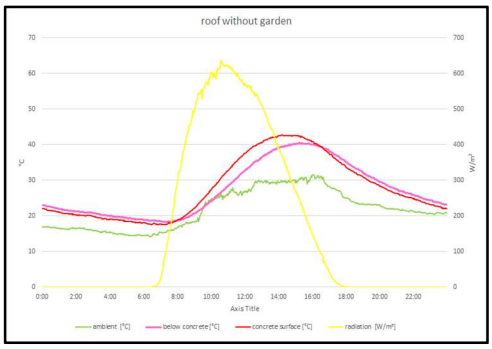

Figure 14: Data from the experiment without rooftop garden.

Figure: 14 compares the temperature of the rooftop without garden to the ambient temperature and the solar radiation. The temperature on the surface as well as the temperature below the concrete are both higher than the ambient temperature. One can see that in the night and early morning the temperature below the concrete is higher. When the sunlight is hitting the surface temperature both temperatures increase. The surface will become the hottest point with about 43°C. The concrete is collecting heat by receiving solar radiation. Even after the solar radiation decreases this temperature will remain for some time and decline in delay. Due to heat transfer the temperature below the concrete stays very close to the surface temperature.

Although there is no more solar radiation, the concrete surface temperature is still relatively high and will give heat to its surroundings during the night. This effect is known as urban heat island.

Figure: 15 shows the temperatures of the rooftop concrete with and without garden. This graph compares the change of temperature of the two different models over time. Without garden the concrete surface has a maximum temperature of 42.7 °C and a minimum temperature of 17.5 °C. The maximum temperature of the concrete surface with garden is 29.3 °C and the minimum temperature is 26.7 °C. In the area below the concrete there is a maximum temperature of 40.6 °C and a minimum temperature of 18.2 °C without garden. With garden below the concrete there is a maximum temperature of 29.6 °C and a minimum temperature of 26.7 °C. Therefore, we can conclude that the rooftop garden can reduce the variation of temperature in the concrete and the room below.

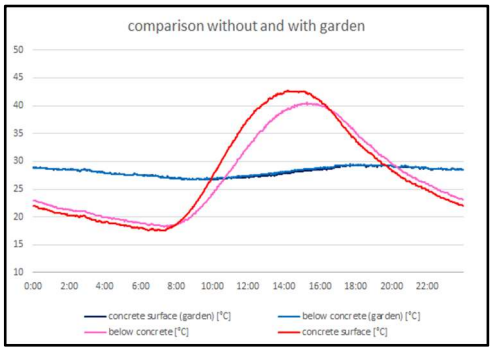

Figure 15: Data from the experiment with rooftop garden.

The garden decreases the temperature variation on the concrete surface by 89.6% and below the concrete by 87.1%. So, the temperature at the concrete with garden is more stable. This is due to the effect of insolation which will prevent extreme temperature changes during the day.

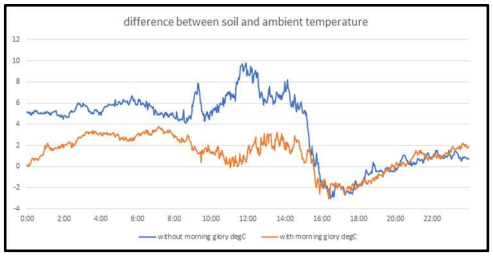

Figure 16: Showing the difference between soil temperature and ambient temperature with or without growing plants.

Comparing the temperature difference between soil surface and environment one can notice that with chinese morning glory the temperature difference is lower than without plants. In this case it is reduced up to 65%. This can be explained by solar radiation. Without plants the sun will hit the soil and heat it up while with plants the sun will hit the plants while the soil is shaded.

From the experiments results it can be concluded that the concrete accumulates heat and that there is a great variation of temperature. A rooftop garden acting as an insulation allows to reduce the variation of temperature during the day. This variation is decreased at the concrete surface by 89.6% and at the surface under the concrete by 87.1%. This shows a good insulation ability for the rooftop garden. The planting of Chinese morning glory reduces the difference between soil surface and ambient temperature by 65%. The RTTV is calculated to analyse the heat flow through the rooftop (Leong, A., 2009), defined as

$$RTTV_{ni} = (U_r)(1 - SRR)(TD_{eq}) + (U_s)(SRR)(\Delta T) + (SC)(SRR)(SHGC)(ESR) \quad (3)$$

Where

$RTTV_{ni}$ is total heat transfer over considering roof top area.

U_r is overall heat transfer coefficient of roof top.

SRR is the ratio of translucent roof top area with considering roof top area.

TD_{eq} is temperature different equivalent between inside and outside building.

U_s is overall heat transfer coefficient of translucent roof top.

ΔT is temperature different between inside and outside building.

SHGC is heat transfer coefficient from solar radiation trough the translucent roof top.

ESR is solar irradiation incident translucent and/or opaque surface.

Since there is only one opaque single layer of rooftop the RTTV can be calculated calculated with a k-value of

$k = 1.442$ W/m·K

the thickness of the wall of

$\Delta x = 5$ cm

and the following equation

$$RTTV = \frac{k}{\Delta x} \cdot \Delta T \quad (4)$$

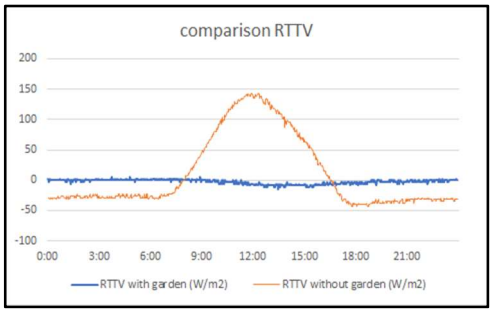

Figure 17: Comparing the RTTV of both cases.

Figure: 17 is showing the RTTV of both scenarios by minus and plus show direction of heat outflow and heat intake to the rooftop respectively. Without garden the RTTV of the rooftop varies between -44 W/m² and 136 W/m². With garden the RTTV is very stable only varying between -12 W/m² and 6 W/m². So, the rooftop garden decreases the average RTTV by 122.5% from 11.0 W/m² to -2.5 W/m².

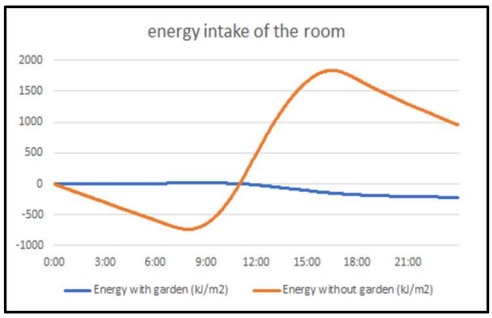

Figure 18: Comparing the energy intake of the room through the rooftop in both cases.

Figure: 18 showing the total energy transfer through the roof states that without garden there is 960 kJ/m² Energy transported into the room. With garden this number is only -215 kJ/m². This is a decrease of 122.5%.

4 CONCLUSION

Many factors influence the data collection and thereby the outcome of the cooling and energy saving effect of vertical farms and rooftop gardens. Especially the thickness and material of the wall, the orientation and exposure to the sun, the ambient temperature and the seasons affect the outcome of the study. Therefore, it is hard to make a general statement about the scale of this study, due to its short period of research, approximately 4 months and financial obstacles, which made it hard to improve on some errors. Still the results show that employing green edible facades have a significant effect on heat transfer and should be further investigated.

In the case of the chosen test wall the Bamboo-Ponics reduced the energy transfer by 343%. The rooftop garden reduced the energy transfer by 123%. Both the Bamboo-Ponics farm and the rooftop garden decrease the heat intake by day. While the rooftop garden also decreases the heat transfer from inside to outside during the night, the Bamboo-Ponics farm does not prevent the wall from transferring energy out of the room. This means in the night more heat is transferred from inside to outside than it is transferred from outside to inside during the daytime.

Another beneficial effect regarding the rooftop garden is its good insulating ability. It reduces the temperature variation during the day by 90% on the outside surface and by 87% on the inside surface. This study shows that energy saving can be combined with multiple economical returns from selling the agricultural products and lower the cost for cooling. At the same time, it is lowering GHG emissions occurring from heating, food transport and food waste. This research is demonstrating the energy and resource saving opportunities of urban farming. Globally the demand of energy and natural resources is increasing. To deal with this task it's not only necessary to produce energy sustainable but also use energy and natural resources more efficiently. Providing people with local food from a smart farming method that simultaneously is saving energy is a perfect improvement to this current situation.

It is important to show the big scale of opportunities vertical farming and rooftop gardens can provide. There is more research and development necessary to shift more attention to the cross financial and environmental benefits of urban farming. Publishing this paper is to draw attention to the threat the agriculture industry currently is facing as the water cycles are changing and temperatures are rising. Further R&D in covering buildings walls and rooftops with agriculture in tropical climates can provide a new energy saving properties and contribute more education and easy to handle farming solutions. At the same time, it can provide a Return of Investment to engage the private sector in smart farming. We accomplished to demonstrate an innovative idea of combining agriculture and energy efficiency.

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Learning Organizational Factors of Travel Business Agencies in Chiang Mai Province

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Abstract: The research on learning organizational factors of travel business agencies in Chiang Mai Province used two sets of tool for data collection: a questionnaire for 167 travel business agencies s in Chiang Mai Province. The study data produced the finding as follows: 1) learning factors of organizational staff members contributed the highest average and 2) team learning as well as the participation of the leaders provided successive average. In addition, the results from exploratory factors analysis (EFA) found six new factors including 1) team learning in organizations 2) participation of staff members 3) self-development of staff members 4) learning promotion in organizations 5) creation of learning atmosphere, and 6) systematic working. These new factors motivated the personal to work together efficiently. Consequently, this also resulted in organizational engagement leading to less resignation of the staff. The significant relationship was statistically formed at 0.01.

Keywords: Learning Organizations, Human Resource Management,
Travel Business Agencies in Chiang Mai Province

1 INTRODUCTION

Tourism industry has been a highly-expanding industry which plays a very important role to Thailand's social and economic systems. It is a major source of a large seen of incomes from both inside and outside the country (Ministry of Tourism and sports, 2017). Not only is it helps to create jobs and to distribute development to various regions and communities throughout the country. Tourism is a hospitality service management which concern human activities, especially direct business namely travel agencies, hotels, restaurants, outlets and souvenir shops etc. Nowadays, Thailand enters aging societies effecting lacking both the quality and quantity of skilled labours. Also, Thailand now faces restriction on increasing the ability to compete for the promotion and development of human potentials, relevant to the main purpose of this plan which puts the emphasis on human resource development in education, learning and developing skills for economic potentials of the country (Office of the National Economic and Social Development Council, 2016) and for working effectively and efficiently (Ministry of Labour, 2016)

The benefits of human resource development in tourism industry involved every group: executives or managers, academic personal, and employees to be able to manage sustainable tourism and use practical knowledge (Ministry of Tourism and Sports, 2015) Chiang Mai can provide best tourism potentials and prominently international service as well as many different tourism assets (Provincial Administration Development and Promotion Bureau, 2014) The report on the study of Chiang Mai Potentials in Tourism 2015-2018 found that the province had its weakness in labours, Even though, there was an expansion of tourism and services, the increase in labours and job employment were needed accordingly. This resulted in the lack of workers. The High competition in labour markets wage increasing policy of the government and entering ASEAN community allowed high potential employees to leave the low-paid companies to work for the well-paid ones. Besides, the findings of the study showed that increasing both tangible and intangible wages, creating organizational engagement, and supporting employees to work were important parts the agencies should have taken into consideration to maintain high quality employees (Hay Group, 2016)

From the points mentioned above, the researcher; therefore, was interested in conducting the research on Learning Organizational Factors of Travel Business Agencies in Chiang Mai, especially in Muang Sub-district aiming to develop human resource management, promote working efficiently, reduce resignation rate, create and good human resource management system, gain a competitive advantage build learning organizations for effective work, make profits and attracts customers to come back.

2 RESEARCH OBJECTIVE

To analyse learning organizational factors of travel business agencies in Chiang Mai Province.

3 LITERATURE REVIEW

A learning organization is the organization is the organization with the vision originated through learning within the organization itself. It is also the organization offering every sector the opportunity to learn (Watkins& Marsick, 1992) leading staff to change and adjust themselves to the working environment continuously (Paddler, Burgoyne, & Boydell, 1997). Later, staff can build the atmosphere with the corporation of every level of staff members with the main purpose of the organizational responsibilities. Analysing and solving problems based on the organization are required. Planning and strategic improvement are considered for the change of the environment (Garvin, 1993). Organizational thinking integration is aimed to understand learning organizations as well.

However, the important factor of learning organizations is the personnel or human beings while tools, office equipment or other various techniques as well as information technology system are only support facilities to reach learning organization. Learning has to be systematic; staff members learn continuously, share knowledge from experiences and experiments, and transform knowledge to others within the organizations; and personnel can be able to being experience and expert knowledge or skill to add value to their products and services creatively, II factors of learning organizations are used to do as mentioned (Kitapci & Comez, 2017). In addition to II factors, there are others factors being developed to form learning organizations. Among them are organizational culture which includes creating atmosphere for

learning, transforming learning openly (Mingjeong & Minjung, 2017) giving inspiring award, using information technology with personal's skills and experiences, applying knowledge as a beneficial adding value factors. For support factors (Marquardt, 1994), precise vision will enhance staff to be more enthusiastic to learn, to construct knowledge and to be more competent for the same learning target (Segne, 1990, Burgoyne and Boydell, 1991). Furthermore, promoting learning organizations must involve knowing how to learn, how to make every level of staff member recognize the importance of learning, how to work as a team, and how to encourage them to think and work systematically (Panitamai & Wutrong, 2014). In accordance with the practical thinking approach of Watkins and Marsick (1992), learning occurs naturally in our daily life when we can control our self-learning.

From analysing the thinking approach mentioned before, the researcher could summarize the characteristics of learning organizations of travel business agencies in Chiang Mai by using 7 factors as follows: 1) learning of organizational staff members, 2) team learning, 3) positive learning atmosphere, 4) participation of executives, 5) sharing learning, 6) being conscious, and 7) systematic thinking. In fact, the 7 factors are purposely used as the guidelines for developing organizations with the emphasis on team learning and for transforming or exchanging body of knowledge experience, and skills. As a result, the organizations will be updated and kept pace with the changing situations and competition as well as effective working process and efficient working results of the organization and staff.

4 METHODOLOGY

The population for this research was the staff members of 167 travel agencies in sub-district, Chiang Mai Province. The questionnaire used to collect data was constructed based on related thinking approaches, theories, literature and researchers. The structure of the question items also covered the scope of content and the objective of the study. The means and standard deviations were analyzed. After that the exploratory factor analysis was used to classify each factor namely Pearson's Product Moment Correlation coefficient, Kaiser-Meyers-Olkin Measure of Sampling: KMO, Adequacy, Communality: h2 , Total Variance Explained, and Rotated Component Matrixa, Accordingly, new six factors were obtained.

5 RESULTS

For the learning organizational factors of travel agencies in Chiang Mai Province, subjects were female aged between 26-30, and holding a bachelor's degree. Their income was between 10,000-20,000 baht per month and work duration was between 2-5 years. The researchers analyzed the factors mentioned one by one in order to find their indicators and the finding were as follows:

Table 1 : Comparison of means and standard deviations of learning organizations staff in Travel agencies, Chiang Mai.

Items	Means	Std. Deviation	Results
1.Learning of organizational staff members	0.55	4.53	High
2.Team learning	0.59	4.51	High
3.Participation of leaders	0.62	4.51	High
4.Positive learning atmosphere	0.63	4.49	High
5. Sharing learning	0.61	4.47	High
6. Being conscious	0.59	4.46	High
7.Systematic thinking	0.62	4.44	High
Total	**0.60**	**4.49**	

Table 1 displays the mean rank and Standard Deviation of the questions about learning organizations staff members in the travel agencies in Chiang Mai. The mean rank starts from 4.41-4.66 and Standard Deviation from 0.50-0.69. The first three issues ranking successively from highest to lowest are learning organization 'staff members, team learning, and participation of executives, However, the results of 7 factors are as follows:

1) For learning of organizational staff members, the findings shows that searching for knowledge beneficial to develop their organizations ranking the highest (Mean = 4.66); being enthusiastic to learn (Mean = 4.62), being determined to develop their potentials (Mean = 4.54), and promoting continuously from their organizations (Mean = 4.44) rank successively,

Learning new things ranks the lowest (Mean = 4.41)

2) In terms of team learning, the results display the ability to convey received information to other colleagues ranking the highest (Mean = 4.59). The successive ranks are being able to work with others in their organizations (Mean = 4.53), exchange their knowledge and experience among staff members and team work (Mean = 4.52) collaborating with others and receiving problem solving from others (Mean = 4.50), planning team working with others (Mean = 4.49), and being reliable in working with colleagues (Mean = 4.49).

3) As to the participation of executives, supporting learning of staff members well ranks the highest (Mean = 4.59) while defining directions and policies of learning within organizations (Mean = 4.55), good leadership of executives when having problems in working (Mean = 4.47) rank successively. The lowest ranking is evaluating clearly and appropriately of the executives (Mean = 4.46).

4) With regard to positive learning atmosphere, the item with the highest rank in having opportunity to share and hear opinions from colleagues (mean = 4.42). The successive ranks are supporting from colleagues in learning (Mean = 4.41), expressing opinions freely about working (Mean = 4.41), promoting learning from organizations (Mean = 4.40) and the lowest rank is developing flexible format of working (Mean = 4.38).

5) For sharing learning, the results show that exchanging problems and solving the solutions to the problems within the organizations are ranks the highest (Mean = 4.52). The successive rankings are sharing knowledge within the organizations (Mean = 4.51), supporting and hearing colleague's opinions (Mean = 4.46) and expressing opinions beneficial to the organizations (Mean = 4.44). The lowest ranking is good system of storing organization's information (Mean = 4.43)

6) In term of being conscious, the highest ranking is developing one self's thinking patterns all the time (Mean = 4.54), the ability to analyze and settle the problems appropriately (Mean = 4.53), readiness to adjust themselves to organizational changes (Mean = 4.43), the ability to adjust themselves to any situations and environment (Mean = 4.41), and the lowest ranking is giving lists of priorities to do things (Mean = 4.40).

7) For systematic thinking, the findings showed that the ability to work systematically ranks the highest (Mean = 4.47). Building good images for the organization (Mean = 4.47), the ability to plan the organization's work relevant to its objective (Mean = 4.44), and the ability to face and solve problems on their own (Mean = 4.43) are ranking successively. The lowest ranking is the ability to solve the problem of complicated work (Mean = 4.41).

Besides, the findings of exploratory facts analysis, classified by factors including Pearson's Product Moment Correlation Coefficient, Kaiser-Meyer-Olkin Measure of sampling **:** KMO Adequay, Communality**:** h_2 , Total Variance Explained, and Rotated Component Metrix a, are as follows**:**

The finding of Pearson's Product Moment Correlation coefficient showed that the correlation coefficient within the discourse has a statistically significant relationship at 0.01 and 0.05 with the total of 63 **%.** Moreover, the results of checking the appropriateness of using factors analysis found that Bartlett's Test of Sphericity which is used for Chi-square matrix correlation coefficient is 2357.469 $p<0.01$ showing that the correlation coefficient matrix of indicators differs significantly from that of identities overall the sample groups are very suitable**.**

Table 2: Showing the results of KMO are Bartlett's Test of factor 1 for further factor analysis.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.775
Bartlett's Test of Sphericity	Approx. Chi-Square	2357.469
	df	630
	Sig.	.000

The result of communality analysis h2 of learning of organizational staff members in travel agencies in Chiang Mai indicated that communality h2 started from .603-.802. In other words, the values more than 0 contributed to the ability to explain the variance of variable in each item and therefore all factors can share the same analysis.

Total variance explained, Eigenvalue, percent value of variance and percent value of accumulated variance of questions, used for evaluating share factors of learning organizations found that the indicators gaining percent of variance = 8.270/36 X 100 = 22.971 %. This meant that indicator 1 could explain 22.971% of the entire variance. Indicators2 = 2.43/36 X 100 = 6.731 % of variance and this meant the indicator

2 could explain 6.731% the entire variance. Therefore, the six factors of learning organizational staff members could explain 38.884 % of the variance value of 36 items which were enough to be representative of the factor due to more than 1 of Eigen value .From the analysis of survey factors, the Rotated Component Matrixa value of the learning organizational factors with 7 items contributed to new six factors as follows :collaborative learning in organizations, participation of staff members, self-development of staff members, promoting learning in organizations, creating learning atmosphere, and systematic working.

6 DISCUSSION

Collaborative learning in organizations enhanced staff members to listen to others' opinions and was beneficial to the organizations . Work planning collaboratively resulted in reaching the workplace's goal. Every organization emphasized collaborative learning, encouraging staff to think and act out, team work, and working together happily. As a result, the staff could have the opportunity to learn together, understand each other, and know their responsibilities and the need of their organizations.

The staff sometimes dared not express their thoughts freely because Thai people were very considerate to their leaders and colleagues (Mathis & Jackson, 2002) Since Thai people were considerate, the frequency of holding meetings differed from organization to organization. Small workplace staff feel relaxed and east when talking, expressing opinions or exchanging knowledge, expressing opinions are exchanging knowledge and problems. On The contrary, big organizations held the meeting with fixed and well-prepared agenda so that participants could prepare the information to exchange and discuss in the meeting. Also, the participants could share their opinions and accept the thoughts of others. These two ways promoted collaborative learning and formed learning organizations (Aleksandra, Blawat, 2014).

The Results of learning organizational factors of travel agencies concluded that this factor supported good learning because the staff developed both the environment in the workplace and themselves .Moreover, their leaders encourage them to work enthusiastically with good working systems, learning new things at all times helped them work accurately. The more they experienced their learning the better they could work. (Eisele et al, 2013) And this was relevant to the researchers of Hong Bui and Yehuda Baruch(2010), and Pedler et al. (1997) the individuals contributed to learning organizations .Accordingly, staff would implement their knowledge to improve their work and their organizations simultaneously .Self-Development made staff enthusiastic to learn constantly (Padler et al, 1997) and learning of staff in organizations was a vital factors effecting being real learning organization. These organizations emphasized the fact that their staff could be able to develop their potential for learning new ideas and various working skills and this could bring about good quality of work (Amporn, 2014).

In addition, the finding revealed that the factor of team learning was very significant for exchanging ideas among staff within the organization helping each other to solve problems and also encouraging staff to express their opinions. Since team learning allowed staff to share their knowledge and learn in groups . Besides, it was a procedure to blend their knowledge for new innovation in their organizations .Seminars and training were useful for knowledge exchanging and reflecting their ideas from doing this, suitably conducted by their leaders (Doving and Rubio, 2013).

Regarding participation of the executives, these factors showed that staff's executives or leaders supported their learning very well which was relevant to the thinking approach of Walkins & Marsick (1992). Both stated that strategic leadership for learning was a format which supported within the organizations. The agencies set strategies for organization learning clearly, relevant to Dararung (2015) stating that clear policy identification was a guideline to reach the intended target. The executives had to set their visions for better understanding of all staff, set clear evaluation system, and promote as well as express their responsible behavior of learning and sharing their knowledge continuously.

In term of positive learning atmosphere factor, staff had the opportunity to share and hear their peers' opinions, relevant to the thinking approach of Bui & Baruch (2010) and of Kongyangyune (2017) which indicated that organizational atmosphere created staff's behavior of being good members, sharing knowledge to improve their own work. Improving working atmosphere positively in the travel agencies enhanced the staff to learn more.

For sharing learning factor, the results showed that exchanging problems and finding

solutions among staff in the organizations were relevant to Peter Senge (cited in Payak Wutnarong, 2014). This explained that exchanging knowledge and opinions of staff in the workplace was beneficial to develop staff's knowledge and ability. Sharing knowledge was a means of exchanging information and sharing experience beneficial to the organizations, and Endres & Rhoad (2016) found that sharing learning played a vital role in the organization work .This worked well in the proper atmosphere and would result in motivation, opportunity, ability to work, adjustment to different situations, and readiness for facing incoming problems .All these items promoted effective work.

Concerning being conscious factor, the finding showed that staff members kept developing their own thinking paradigm Peter Sege cited in Wutnarong (2014) claimed that thinking paradigm, perspectives and understanding organizations for decision making which effected understanding in work and various activities of the organization .Similarly, Liu et al (2015) found that being conscious was important to help find the solutions to work problems, especially, the complicated work, planning for development system, and sharing knowledge within organizations. Furthermore, being conscious was also a tool for connecting duties and restricted work system in order that the assigned work could be done with practical and efficient procedures.

For the factor of systematic thinking, the finding indicated that systematic thinking created good image for the workplace and promoted the ability to set the working plan in line with the objectives of the organizations .Systematic thinking involved looking at the entire problems and solving them positively .This would help solve very complicated problems creatively (Sadeghi, 2014). Also, systematic thinking enhanced the staff to understand their working system well, their working processes, their working load, and to be able to work efficiently (Khunpreum, 2011)

In addition, collaborated learning of staff members in travel agencies in Chiang Mai, the executives tool part in supporting learning and being learning organizations. Staff members should have known the directions and policies in supporting learning in organizations. One more important thing was the executive's leadership for developing, learning organizations. The leaders had to be good samples who were able to convey their vision clearly, evaluate learning organizations systematically, develop staff to be able to learn by themselves, create learning atmosphere beneficial for learning, emphasize working in teams, participate and distribute power for decision-making, help staff when having work problem (Apicha Taneerat, 2016). Furthermore, collaborated learning in team reinforced learning significantly. The results of the study revealed that transforming knowledge to each other in teams not only created value in working but also forced staff to work efficiently. The staff know the directions of their work; the more they learned how to work in teams, the more efficiently they could work. Since the members exchanged how to analyze problems, convey knowledge, and work in team, they seemed to be pushed to work happily and felt that they were part of their organizations (Dimas et al, 2015). Also, collaborated learning of members was regarded as steps to reach the objectives .Team learning had to rely on exchanging learning in their organizations and proposing new thoughts or new knowledge of members in order to set good work planning, leading to working efficiently of individuals and teams .Problems were solved efficiently .The most important thing that could make team learning possible was the support from the organizations and their leaders as well (Dayaram and Fung, 2012)

Promoting learning in organizations meant that supporting their personnel to learn new things and apply them to responsible work . Sharing learning was important for working in organizations. When staff members shared their knowledge in suitable atmosphere, motivation opportunity to work, adjustment to situations and readiness to face incoming problems would occur and this resulted in efficient work (Endres and Rhoad, 2016) Administrators played an important role in sharing knowledge in the workplace. The administrators and the employees wanted to exchange problems from overloaded work. Sharing learning was not necessary to be awarded in return because sharing knowledge was one way to benefit their organizations and their personnel could learn new things, too (Mueller, 2011). Allowing personnel to express their opinions about working freely along with the learning atmosphere of the organizations were indirectly powerful factors to from real learning organizations which included the factors of administrating, team work development, motivation and working in teams .These factors really helped to form learning organizations (Sasiwimonluck and Wongwut, 2015). Creating learning atmosphere was a format time, the opportunity for development, and the satisfaction of personnel from learning atmosphere .To be good learning atmosphere, the personnel needed

flexibility, freedom to work and opportunity to share knowledge .All these aspects were just part of organizational development and the organizations had good management to support learning .Carrim and Basson (2013) studied comparison of Creating Working Atmosphere of Public and Private sectors created working atmosphere for learning by supporting their personnel with seminars and training with the purpose of offering a chance to share knowledge to each other, reducing working competition among them, and allowing the staff to express their opinions .This was considered that creating positive learning atmosphere encouraged the staff's working development (Choi and Park, 2013) Besides, systematic working was like the organizations' important mechanism because their problems could be solved immediately and right to the point .Managing the organization efficiently required getting trained to be conscious which resulting in acting out and making a difficult decision of the individuals . Each decision making would involve more reasons and experiences to help solve the problems .Also, being conscious contributed to expressing and acting of the personnel; for example, their decision-making and being conscious (Rook, 2013). As to the systematic thinking, it reinforced the staff to be able to analyse, set planning and control changing working procedures .Cause and effects, scientific thinking as well as anticipation were used as working aids in changing environment .Thinking skills would be competence in organization working (Olszaewski, 2015). Developing systematic thinking enhanced learning and learning development systematically. Work experience influenced thoughts .Developing socializing skills and emotions resulted in positive systematic thinking .These concepts were used to develop thinking paradigms, analyse problems and adjust work .These factors enhanced organizational working to develop rapidly (Skarzauskiene, 2010). Therefore, promoting being learning organizations and stressing more importance on learning organizations, in terms of forming learning paradigms, creative thinking formats due to learning in organizations, as well as, working and thinking systems would promote the efficiency in human resource management which was much different from before .In addition, the effective human resource management could respond to the requirement of the customers and when human resource management was effective, the organizations would be able to encounter changing immediately.

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